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ORIGINAL ARTICLES.

Studies in the Corallian Lamellibranch Fauna of Oxford, Berks, and Wilts.

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I. Limidae.

(PLATES XIX–XXII.)

I. Introductory.

A GLANCE at the exhibited collections in any of our leading museums, such as the British Museum, the Geological Survey Museum, or the Oxford University Museum, shows that the naming and identification of many of the Mesozoic fossils is in a very unsatisfactory state. The private collector or the student who becomes thoroughly familiar with the fauna of his own district and then goes to these museums to classify and identify it will usually come away with many misconceptions. He finds, moreover, that the various museums contradict one another.

With the exception of the few enlightened families, localities and strata on which monographs have been written, the whole of our Jurassic Lamellibranch fauna suffers from past attempts to fit English fossils into the species of foreign authors. In most cases the holotype has never been consulted, and in far too many there is little resemblance to the figure. In others a superficial resemblance in the figure has led to the ignoring of a wide stratigraphical discrepancy.

The student who finds cause for anxiety in the showcases of the museums will find chaos when he obtains access to the locked drawers underneath. The mass of raw material secreted in these drawers would provide many workers with a lifetime's research.

If the present papers help to straighten the tangle in at least one small department of our Jurassic Lamellibranch faunas, a part of the extremely rich fauna of the South-Midland Corallian, they will have served their purpose.

I am anxious to thank Dr. F. L. Kitchin, Mr. J. Pringle, and Mr. C. P. Chatwin for the kindness and help they have extended to me while working in the Museum of Practical Geology, and particularly Dr. Kitchin for giving me access to the collections and for sending specimens to be photographed; Mr. L. R. Cox for guiding me through the collections in the British Museum; and Dr. J. A Douglas for continual advice and assistance as well as for the suggestion which brought this paper into being.

II. Stratigraphical Note.

The Corallian Formation will here be considered as extending from the top of the Oxford Clay in a lithological sense as applicable in the Oxford district to the top of the Sandsfoot Grits of Dorsetshire—the Ringsteadian zone of Salfeld. In this district it will be considered as consisting of four parts :

4. *Sandsfoot Grits*, Westbury Iron Ore or Ringsteadian Beds.
3. *Coral Rag* and equivalent limestones with *Cidaris florigemma.*
2. *Oxford Oolites*, a varied succession of extremely fossiliferous oolitic limestones, marls, etc.
1. *Lower Calcareous Grit*, chiefly sands and concretionary calcareous grits.

The details of these stratigraphical divisions, and the reasons for choosing the names, I hope to discuss in a forthcoming paper dealing with the geology of the formation.

Many of the fossils have been obtained from the Coral Rag, but by far the greatest number are found in the Oxford Oolites. The Lower Calcareous Grit is poorly fossiliferous and the Sandsfoot Grits are nowhere exposed north of Westbury.

The Oxford Oolites attain their maximum thickness of 34 feet at Highworth, 25 miles south-west of Oxford. East and west, at Headington and in the neighbourhood of Purton and Wootton Bassett, they thin out to a shell bed from 1 foot to 2 feet thick. This shell bed also contains rolled pebbles similar to those which are everywhere found at the base of the Oxford Oolites, and it will here be spoken of as the Shell-cum-Pebble Bed.

Where fully developed the Oxford Oolites consist of the following components, to which reference will be made in noting the localities and stratigraphical positions of the species[1] :—

Pusey Flags.—False-bedded oolitic sandstone flags. Maximum thickness 15 feet.

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[1] See W. J. Arkell, in S. S. Buckman's *Type Ammonites*, V, 1925, pp. 55–61.

Highworth Grit and Clay.—Formerly much used for bricks. Poorly fossiliferous. Maximum thickness about 12 feet.

Urchin Marls.— Highly oolitic marls full of *Echinobrissus scutatus* and *Pygaster umbrella.* A very constant feature. Max. 6 feet.

Trigonia Bed Limestones.—Shelly limestones with early coral reefs at the base. Highly fossiliferous. Max. thickness c. 12 feet.

Pebble Bed.—1 foot to 2 feet 8 inches. Very constant.

For the purposes of this paper the whole of the Oxford Oolites may be considered as belonging to Salfeld's zones of *Perisphinctes martelli* and *Perisphinctes antecedens.* The exact age of the Coral Rag is doubtful, for only a very few fragmentary ammonites have been found in it, but it may be safely regarded as probably belonging to the upper part of Salfeld's *antecedens* zone. At the top of the Coral Rag there is an important faunal break.

III. Diagnoses.

In the following descriptions only such characters will be mentioned as are of specific value. The generic characters will be stated at the beginning. For the sake of uniformity and to facilitate quick identification, already established species will be redescribed on a common basis. Many of the old authors repeated in every specific diagnosis such generic characters as " convex, oblique, hinge-line straight ", etc., which only obscure the important characters by means of which the species may be distinguished from one another.

Wherever possible the holotype has been used for description, and, failing that, topotypes or typical specimens of established authenticity from other localities. In many cases it has, of course, been necessary to emphasize characters not considered of sufficient importance to be mentioned by the original author, or inadequately represented in his figure, but which it may be safely assumed lay unrevealed in the now inaccessible or lost holotype.

One new term has been introduced to describe a character of great importance, to which no existing designation seemed applicable—*Escutcheon Ridge.*[1] The escutcheon ridge is that part of the shell occupied in *Trigonia* by the Carina ; or in other words the boundary of the escutcheon area. When the shell is viewed from above perpendicularly to the surface this ridge rises prominently from the angle formed by the junction of the posterior and ventral margins to the umbo. In some shells its outline thus viewed is convex, in others it is straight, in others concave, and it may or may not hide the posterior auricle.

In counting ribs or sulci the count is always taken from the junction of the anterior auricle with the margin, round the shell, keeping fairly close to the margin, to the escutcheon ridge. At the escutcheon ridge there is usually, as in *L. mutabilis,* a marked interruption of the ribbing, only a few irregular ribs existing posterior to it. In other species, however (e.g., *L. subantiquata*), the ribbing or sulcation is continued without perceptible change all over the escutcheon.

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[1] Term suggested by Mr. C. J. Bayzand.

The practice of Continental writers of collecting together every possible mention of a species into a long synonymy has been avoided. When all items of such synonymies are inquired into they are seldom found to be reliable and confusion is increased instead of being reduced. Only good figures in the more important foreign works are mentioned, together with a few references to the rocks of the Oxford district which might lead to misunderstanding if they were overlooked. References to such works as *Lethea bruntrutana* are usually purposely omitted, as the figures in the case of Pectens and Limas are not sufficiently accurate for certain identification.

IV. NOTE AS TO MEASUREMENTS.

In accordance with the rules of palaeontology the length of a Lamellibranch shell must be measured parallel to the hinge-line and the height in a direction at right angles to the hinge-line from the umbo to the opposite margin. A third measurement, the inflation, is usually added ; this is measured at right angles to the direction of the other two measurements.

The shells of Limas, however, are so oblique that those measurements give no true idea of the shape of the shell. In many Limas the greatest diameter lies in a direction making an acute angle with the hinge-line, and such shells are of an entirely different shape from others more nearly equilateral ; yet the " length " and " height " measured as described above may have the same values in both cases.

As an improvement on the existing methods of measurement I have in the following descriptions always added a fourth dimension, by means of which the obliquity may be expressed. This measurement is taken from the tip of the umbo to the furthest point on the margin. In shells which are nearly equilateral, such as *L. rigida*, this figure is identical with the height. In oblique forms, such as *L. highworthensis* and *L. elliptica*, it is proportionately greater than the height.

The four measurements described will in every case be arranged in the following order (expressed, of course, for the sake of comparison, as percentages of one measurement, for which purpose the length is usually chosen) :

	Length.	Height.	Obliquity.	Inflation.
L. elliptica	11	91	123	54½
L. rigida	55	110	110	72

The first column shows the length of a typical full-grown individual in millemetres. The second column shows the height. The third column shows the maximum distance from the umbo to the ventral margin. The fourth shows the total thickness of the shell *through both valves.*

By comparing the second and third columns it can be seen at a glance that, while the greatest diameter is identical in *Lima rigida* with the height and therefore the measurements must have been made practically along the same line (i.e., the shell is nearly equilateral), in *L. elliptica* it is 32 per cent. greater than the height, and therefore the point on the ventral margin furthest from the umbo must lie a proportionate distance towards the posterior, i.e. the shell is extremely oblique.

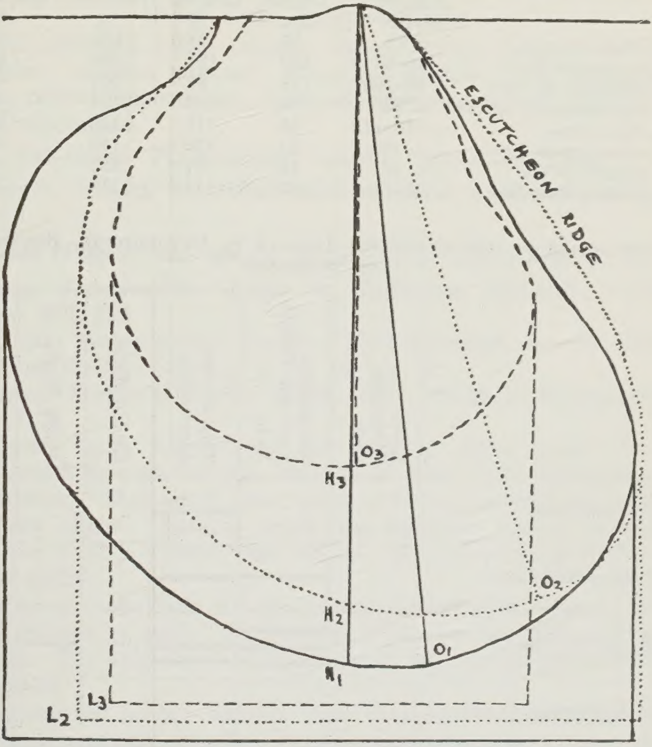


FIG. 1.—Tracings from photographs of (1) *Plagiostoma mutabilis* nov., (2) *P. highworthensis* nov., (3) *P. rigida* Sow., superposed on a common hinge-line to show methods of comparison of form. (Diagrammatic.) $L_1 L_2 L_3$ = Length; $H_1 H_2 H_3$ = Height; $O_1 O_2 O_3$ = Obliquity.

Thus, when all the species are tabulated as in the accompanying table, it is possible to picture fairly accurately and quantitatively the relative differences and similarities in form of the various species without reference to descriptions, which must always be unsatisfactory because of their qualitative limitation. A species which has been first identified by means of these measurements may then be verified by turning to the description of the ornamentation.

COMPARATIVE TABLE OF THE CORALLIAN LIMIDAE OF OXFORDSHIRE, BERKSHIRE AND WILTSHIRE.

	Number of ribs.	Length. mm.	Height. %	Obliquity. %	Inflation. %
P. zonata sp. nov. .	. *c.* 85	25	98	108	48
P. laeviuscula Sow.	. 50–60	110	101	104	42
P. mutabilis sp. nov.	. 85–100	118	97	100	42
P. highworthensis sp. nov.	. *c.* 82	76	102	107	49
P. rigida Sow. .	. 110–115	55	110	110	72
P. subantiquata Roem.	. *c.* 130	31	136	136	32
L. elliptica Whit. .	. *c.* 14	11	91	123	54
C. proboscidium Sow.	. 10–14	123	115	115	37

DISTRIBUTION OF THE CORALLIAN LIMIDAE IN OXFORDSHIRE, BERKSHIRE, AND WILTSHIRE.

	Lower Calcareous Grit.	Headington Shell-cum-Pebble Bed.	Trigonia-bed Limestones.	Urchin Marls.	Pusey Flags.	Coral Rag.
P. zonata nov. . .			—			≡
P. laeviuscula Sow. .		—	—			
P. mutabilis nov. .		≡	=	……	—	—
P. highworthensis nov. .						—
P. rigida Sow. . .		≡	≡	—	—	—
P. subantiquata Roem. .			—	—		
L. elliptica Whit. .	—	≡	≡	—	=	≡
C. proboscidium Sow. .		—	—	……	—	≡

Common ≡ Local = Rare —

IV. SPECIES KNOWN WITH CERTAINTY TO OCCUR IN OXON, BERKS AND WILTS, AND VERIFIED IN EVERY CASE BY MYSELF BY COLLECTION IN THE FIELD.

Family LIMIDAE d'Orbigny.

Shell equivalue, convex, auriculate, gaping, monomyarian, edentulous or with traces of taxodont dentition.

Genus LIMA Bruguière, 1792.

Shell obliquely oval, anterior region usually larger than the posterior; auricles unequal; hinge-line straight; area triangular with a central ligament pit; large adductor impression; two small pedal impressions.

Sub-Genus PLAGIOSTOMA, usually known as *Lima*.

Smooth, or with fine radial striae or costae or rows of punctae, or both.

Lima (*Plagiostoma*) *zonata*, sp. nov. (Pl. XXII, Figs. 1, 2.)

? *Lima densepunctata* Blake & Hudleston, *Q.J.G.S.*, xxxiii, pp. 289, 292.

Non *Lima densepunctata* Roemer, *Versteinerungen des Norddeutschen Oolithen-Gebirges*, p. 79, pl. xiv, 3.

Geological Survey Coll. Nos. 43126, 43127, 43128 (5 individuals), 43129.

(All with Coral Rag matrix, all labelled *Lima rigida* Sow.) British Museum Coll. No. 20218 (J. F. Blake Coll., Hillmarton.)

Diagnosis.—Shell small, never much exceeding one inch in length. Obliquity slight. Auricles small, the posterior auricle invisible when the shell is viewed from above. Escutcheon ridge concave. Margin entire.

Surface smooth, dark and glossy, ornamented with about 85 fine radial grooves or sulci. Each sulcus bears a single row of dense punctae. The sulci show no tendency to fade towards the centre of the shell.

As preserved in the English Coral Rag the shell is always in addition ornamented superficially with conspicuous white concentric growth lines. At intervals many of these coalesce to form a broad white banding or zoning, reminiscent of the alternate black and white annular ornament often seen in the recent shell *Mactra solida*.

Dimensions :—

Length.	Height.	Obliquity.	Inflation.	Number of sulci
25 mm.	98	108	48	about 85

Notes.—The characters of this shell are subject to little variation. The curious black and white concentric zoning is apparently peculiar to the species, and affords a ready means of recognition in the field, for it has been present in every specimen I have seen.

Horizon and Localities.—*L. zonata* is the most characteristic

Lamellibranch of the "coral fauna". It occurs with *Chlamys nattheimensis* De Lor. wherever reef-building corals abound. Though commonest in the Coral Rag, it also occurs in the local reefs of Trigonia-bed age near Highworth.

Lima (*Plagiostoma*) *laeviuscula* Sow. (Pl. XIX, Figs. 1–4.)

Plagiostoma laeviusculum Sowerby, *Mineral Conchology*, vol. iv, p. 112, pl. 382.

Non *Plagiostoma laeviusculum* Goldfuss, *Petrefacta Germaniae*, p. 84, pl. cii, 3.

Non *Plagiostoma laeviusculum* Phillips, *Geology of Oxford*, pl. xiii, 23 (inaccurate figure).

Lima grandis Roemer, *Versteinerungen*, p. 76, pl. xiii, 10.

Lima laeviuscula De Loriol, *Rauracien Inférieure du Jura Bernois*, pl. vii, 6.

British Museum Coll. Nos. 70464, 47456 (*a* and *b*), 23366, 23378, 47458 (all from Malton Oolite).

Geological Survey Coll. No. 43118 (Malton Oolite).

Diagnosis.—Shell large, sometimes attaining a length of 120 mm.; depressed, obliquity small, old age forms becoming somewhat orbicular. Auricles small, the posterior auricle invisible when the shell is viewed perpendicularly to the surface. Escutcheon ridge straight to slightly concave. Margin crenulated.

Surface ornamented with broad, irregular, undulating radial ribs and sulci of about equal breadth. Sometimes, but more rarely, these fade towards the centre of the shell, as in *Lima mutabilis*. When the shell is completely sulcate the sulci number between 50 and 60. In most young shells and in the umbonal region of well-preserved old ones the sulci are punctate, but the punctae are a very variable feature and in some specimens appear to be practically absent. Other specimens are markedly punctate all over, the punctae changing towards the margin into transverse grooves.

Concentric growth lines numerous.

Dimensions of a Typical Mature Specimen :—

Length.	Height.	Obliquity.	Inflation.	Number of ribs.
110 mm.	101	104	42	50–60

Notes.—Sowerby's holotype is unfortunately lost. In his diagnosis he makes no mention of punctae, and expressly states that the species is " distinguished by the slight elevation of its ribs . . . and the total absence of any striae between them ". (*Min. Conch.*, vol. iv, p. 112.) But he goes on to say that the species is " not uncommon in the Pisolite of Malton ". Now there are six specimens in the British Museum from the Malton Oolite and two in the Geological Survey Museum from the same locality, which proclaim at a glance that they are true topotypes of Sowerby's species; for there are no other specimens from the English Corallian which remotely resemble Sowerby's figure. It is therefore on a study of these that I have based the above diagnosis. No. 70464, B.M. Coll., bears the closest resemblance to the individual described by Sowerby. Traces of punctae are only very obscure and confined to the umbonal region. There are all gradations, however, up to markedly punctate all over, with ornament resembling Roemer's *Lima grandis*. The markedly punctate variety might appropriately be called *var. grandis*.

Horizon and Localities.—Rare in the Shell-cum-Pebble Bed of Headington and Littlemore and in the Pebble Bed of Kingston Bagpuize, Littleworth and Highworth. Although rare in this district (I know of no perfect specimen and have seen only about six incomplete ones), this seems to be the commonest *Lima* in the Malton Oolite.

Lima (*Plagiostoma*) *mutabilis* sp. nov. (Pl. XX, Figs. 1–3.)

Lima laeviuscula Goldfuss, *Petrefacta Germaniae*, pl. cii, 3.
Non *Lima laeviuscula* Sowerby, *Min. Conch.*, vol. iv, pl. 382.
Non *Lima laeviuscula* De Loriol, *Rauracien Inférieure du Jura Bernois*, pl. vii, 6.
British Museum Coll. Nos. 47457, 67369, 50592, 51237, 38932, 24,685, L.11765, L3,627.

Diagnosis.—Shell large, sometimes attaining a length of 120 mm.; somewhat depressed; obliquity slight. Auricles small, the posterior auricle invisible when the shell is viewed perpendicularly to the surface. Escutcheon ridge concave to straight. Margin entire but cut by the sulci, which follow through with no terminal interruption.

Surface smooth, ornamented with straight, narrow, cleanly incised radial grooves or sulci. The floors of the sulci are likewise smooth and devoid of punctae. The sulci frequently fade towards the centre of the shell, and in extreme cases number only five or even three on the anterior margin and as many on the posterior margin, the rest of the shell being smooth and devoid of ornament. In specimens which are completely sulcate the sulci number from 85 to 100, and are disposed at intervals from once to twice their own width. In specimens in which the sulci fade towards the centre they may be separated by intervals six times their own width.

Dimensions of a Typical Mature Specimen:—

Length.	Height.	Obliquity.	Inflation.	Number of ribs.
118 mm.	97	100	41½	85–100

Notes.—This shell is immediately distinguishable from *Lima laeviuscula* Sow. by the narrow, clearly defined sulci, separated by flat as opposed to convexly rounded costae, and by the fact that specimens which are completely sulcate bear from 85 to 100 sulci whereas completely sulcate specimens of *Lima laeviuscula* have only from 50 to 60 sulci. Further, it is never punctate.

It is distinguished from *Lima tumida* Roem. (with which it has been confused) by the invariable complete absence of punctae, by the much straighter escutcheon ridge, which gives less prominence to the umbones, and by the possession of at least 40 more sulci in the completely sulcate state. The punctae in Roemer's figures of *L. tumida* are not conspicuous, while the style of ornament much resembles that of *L. mutabilis*. But Roemer distinctly states (*Versteinerungen*, p. 77). " . . . überall mit tiefen Streifen bedeckt, in denen man queere, ovale Punkte wahrnimmt . . ." De Loriol also states (*Couches Coralligènes de Valfin*, p. 315) that " *L. tumida* is très finement ponctué ". I quote these passages because several specimens have been labelled *L. tumida* in the exhibition cases in Oxford University Museum.

The only figure which appears to represent *L. mutabilis* is Goldfuss's *L. laeviuscula*. I cannot agree with De Loriol (*Rauracien Inférieure du Jura Bernois*, p. 63) in making this synonymous with Sowerby's *L. laeviuscula* and Roemer's *Lima grandis*.

Goldfuss's description (*Petrefacta*, p. 84) exactly agrees with *L. mutabilis*: " . . . Vom Wirbel strahlen zahlreiche, sehr flache und breite Rippen aus, welche nur durch Streifen voneinander getreunt sind. Bei jungen Schalen haben die Rippen fast gleiche Breite; bei ältern dagegen wechseln breitere und schmälere unregelmässig ab, und verschwinden in der Mitte des Rückens, so dass dieser eine ganz glatte Flache bildet."

Variation.—The only marked variation is in respect of the number of sulci. Of about 40 specimens sufficiently complete to admit of the counting of the sulci, which I have examined in the collection of Oxford University Museum, in my own collection and in the British Museum, I have seen only two bearing the same number of sulci. In the Oxford district the commonest form has from 4 to 10 sulci on the posterior part of the shell and from 12 to 25 on the anterior, the whole central part of the shell being smooth. The smoothest specimen I have seen is a left valve with only 6 sulci, three anterior and three posterior. For the smooth varieties with less than 85 sulci I suggest the name *var. lēvis*, the ideal *var. lēvis* being completely devoid of sulci.

Shells with more than 85 sulci are completely sulcate, no smooth band remaining in the middle. This must be considered the normal condition of the shell, for when the umbones of *var. lēvis* are searched with a lens they are generally found to be completely sulcate.

For the variety which retains its sulci all over the shell throughout life I suggest the name *var. sulcatissima*. The latter variety is rare in the Oxford district, but apparently it is the commonest form in the Malton Oolite. It is, of course, the only variety suitable for comparison with other species with a view to identification by means of the number (and therefore width and spacing) of the ribs and sulci.

With sufficient collecting it should be possible to connect *var.*

sulcatissima with the completely smooth *var. lēvis* by a chain of intermediates, each one differing from its neighbours by only one or two sulci. It is doubtful, however, whether this could be achieved by collecting in only one locality. My own material from the Oxford district when compared with that from Yorkshire in the British Museum shows that there is a tendency towards a prevalent number of sulci dominating a restricted geographical region.

I have endeavoured to illustrate these facts so far as is possible with the material available by means of the accompanying simple graph. The sulci have been counted in each case from the anterior and posterior margins inwards and plotted so that each point represents one specimen.

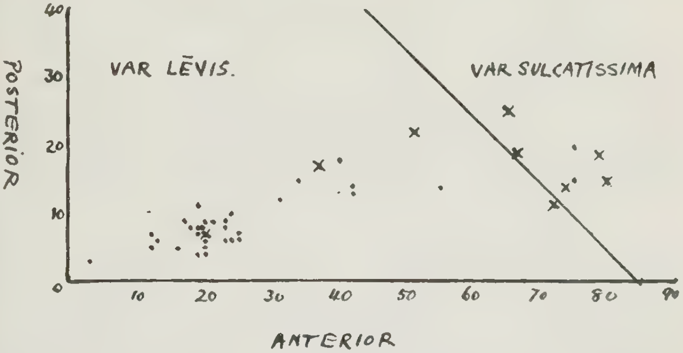


FIG. 2.—*Lima mutabilis* sp.nov. Diagram showing relative abundance of sulci in about forty specimens examined. Specimens from Oxford district represented by dots; specimens from Malton Oolite, Yorks, represented by crosses.

Horizon and Localities.—Very common in the Shell-cum-Pebble Bed of Headington, Littlemore, etc., and in the Trigonia-bed Limestones throughout the district. Rare in the Pusey Flags, Coral Rag and Littlemore Clay Beds.

Lima (*Plagiostoma*) *Highworthensis* sp. nov. (Pl. XXI, Fig. 3.)

Diagnosis.—Shell large, somewhat tumid, produced, markedly oblique. Escutcheon ridge convex. Auricles small, the posterior auricle invisible when the shell is viewed perpendicularly to the surface. Margin entire.

Surface smooth, ornamented with about 82 straight, narrow, clearly-defined, radial grooves or sulci resembling those in *Lima mutabilis*. The sulci are disposed at intervals from two to three times their own width. They are devoid of punctae, and in no known case do they show any tendency to fade towards the centre. They are in general more regular than in *Lima mutabilis*.

The regularity of the ribbing is interrupted four or five times in a marginal band about a centimetre in width by concentric growth lines. This marginal band resembles that in *Lima rigida* and imparts a " finish " to the appearance of the shell not possessed by *Lima mutabilis*. On the rest of the shell growth lines are very faint and inconspicuous.

Dimensions of Holotype :—

Length.	Height.	Obliquity.	Inflation.	Number of ribs.
76 mm.	102	107	49	c. 82

Notes.—This species is closely allied to *Lima mutabilis*, the style of ribbing being identical. It differs from that species, however, in the following respects.

(i) In its greater obliquity, which brings the point on the margin furthest from the umbo about 10° posterior to the corresponding point in *L. mutabilis*.

(ii) In the convexity of the escutcheon ridge, which enhances the appearance of greater tumidity.

(iii) In the rapid falling away of the anterior margin behind the anterior auricle, which produces a greater appearance of obliquity than the figures indicate.

(iv) In the smaller number of sulci.

(v) In the fact that, so far is as known, the sulci do not fade towards the centre of the shell.

(vi) In the marginal band in the mature specimen, in which the radial ornament is rendered zigzag or altogether obscured by closely-crowded concentric growth lines.

Horizon and Localities.—Very rare, and so far known only from the Coral Rag. The holotype is a perfect specimen in Oxford University Museum, bearing an old label " Headington ". The matrix is beyond any doubt one of the " Hard " bands in the " Pendle " or Nodular Coralline Rubble of Workhouse Quarry, Headington, and therefore of Coral Rag age. It contains a spine of *Cidaris*.

Lima (*Plagiostoma*) *rigida* Sow. (Pl. XXI, Figs. 1, 2.)

Plagiostoma rigidum Sowerby, *Mineral Conchology*, vol. ii, p. 27, pl. cxiii, 1.

Holotype in the British Museum, Sowerby Coll.

Lima rigida Goldfuss, *Petrefacta Germaniae*, pl. ci, 7.

Lima rigida Roemer, *Versteinerungen*, pl. xiv, 2.

Diagnosis.—Shell medium sized, tumid. Obliquity nil. Escutcheon ridge concave. Auricles moderately large, but the posterior auricle invisible when the shell is viewed perpendicularly to the surface. Margin entire.

Ornament very distinct from all other English Corallian forms; consisting of 110 to 115 fine radial costae separated by sulci of about equal width. The costae are very variable, some being barely perceptible and others twinned. The sulci are ornamented by fine ladder-like transverse lamellae, which do not cross over the costae.

Concentric growth lines are hardly perceptible on any part of the shell except in a marginal border about ½ to 1 mm. in width in mature specimens. In this marginal border the concentric growth lines obscure the radial ornament.

Dimensions of a Typical Full-grown Individual:—

Length.	Height.	Obliquity.	Inflation.	Number of ribs.
55 mm.	110	110	72	115–120

Notes.—On p. 27 of *Mineral Conchology* reference is wrongly made to pl. xiv, 1, a figure of *L. punctata*, in error for pl. xiii, fig. 1.

Lima rigida is a very distinct species which has generally escaped confusion. In the Geological Survey collection, however, there are eight specimens of *Lima zonata* labelled *Lima rigida*, and in the Oxford University Museum there were exhibited some internal casts of *Lima rigida* labelled *Lima semiornata* Étallon.

Horizon and Localities.—Common and generally distributed throughout the Oxford Oolites and Coral Rag. Particularly abundant in the Trigonia-bed Limestones of Highworth and in the Shell-cum-Pebble Bed of Headington.

Lima subantiquata Roemer. (Pl. XXII, Figs. 3, 4, 5.)

Lima subantiquata Roemer, *Versteinerungen des Norddeutschen Oolithen-Gebirges*, p. 78, pl. xiii, 15.

British Museum Coll. Nos. 47455, 47474. (Both from the Malton Oolite, unnamed.)

Diagnosis.—Shell medium-sized to rather small, of very singular shape. Much compressed; the posterior ventral part of the shell larger than the anterior umbonal. A pronounced ventral elongation makes the height the greatest diameter of the shell, 1⅓ times the length. Obliquity nil. Umbones small and sharp, but not projecting beyond the hinge-line. Escutcheon ridge short and markedly concave, disappearing long before it reaches the margin. Escutcheon small and deeply excavated. Auricles of very unequal size; anterior auricle large and prominent, the anterior margin falling away rapidly behind it; posterior auricle small, but visible when the shell is viewed perpendicularly to the surface, owing to the smallness of the umbo and the concavity of the escutcheon ridge.

Surface ornamented with about 130 unequal, irregularly spaced fine radial sulci, which are continued unchanged over the escutcheon ridge and cover the escutcheon to the additional number of about twenty five, fading on the auricles.

The sides of the sulci are ornamented with numerous minute, regularly spaced dog-tooth incisions. The resulting pattern has the appearance of rows of diamond-shaped depressions, an adequate impression of which can only be conveyed by a micro-photograph.

On the umbones this ornament becomes so minute that it appears as ordinary punctae.

A few rather conspicuous widely-spaced concentric growth lines.

Dimensions of a Typical Specimen :—

Length.	Height.	Obliquity.	Inflation.	Number of ribs.
31 mm.	36	136	32	c. 130

Notes.—The distinctiveness of the shape of this species is only equalled by the peculiarity of the ornament. The ornament is very badly figured by Roemer, but in conjunction with the size, the curious shape, and the spacing of the growth lines, in respect of all of which characters the specimens described above agree very well with Roemer's figure, there seems to be sufficient justification for the identification. The minute ornament is so difficult to draw that it would be a matter for surprise were it adequately portrayed in Roemer's plates, in which the standard of draughtsmanship is not very high.

It is questionable whether this species should be included in *Plagiostoma* ; there is, however, an unlabelled true *Plagiostoma* in Oxford University Museum bearing the oolitic ironshot matrix of one of the Inferior Oolite ironstones, which has an almost identical ornament on a coarser scale. The shape of the shell is quite different.

Horizon and Localities.—Rare. Urchin Marls of Marcham and Shellingford, and Trigonia Bed of Kingston Bagpuize. It is probable that my specimens are of the same species as that recorded by Blake and Hudleston as *L. subantiquata* from the Trigonia-bed Limestones of Highworth (*Q.J.G.S.*, xxxiii, p. 299).

Sub-genus *Limatula* Wood.

Limatula elliptica Whiteaves.

(Pl. XXI, Fig. 4.)

Lima elliptica Whiteaves, *Annals of Nat. History*, viii, 1861, pl. ix 3.
? *Lima duplicata* H. B. Woodward, *Jurassic Rocks of Britain*, vol. v, p. 115.

Diagnosis.—Very small species, not exceeding about 14 mm. in length. Shell rather tumid ; extremely oblique ; produced. Auricles small, but both visible when the shell is viewed perpendicularly to the surface. Escutcheon ridge ill-defined and scarcely a ridge at all. Margin scalloped.

Sides of the shell, including the escutcheon, smooth. Central part ornamented with about fourteen bold radial costae, the anterior side of the shell often showing faint traces of several more. Faint secondary costae occupy the spaces between the primary.

Concentric growth lines almost imperceptible.

Dimensions of a Typical Mature Individual :—

Length.	Height.	Obliquity.	Inflation.	No. of costae.
11 mm.	91	123	54	c. 14

Notes.—This species is closely allied to *Limatula gibbosa* Sow., of the Lower Jurassic, but is considerably smaller.

Horizon and Localities.—Abundant throughout the Oxford Oolites and Coral Rag. Also in Lo. Calc. Grit of Sund.

Genus *Ctenostreon* Eichw.

Ctenostreon proboscidium Sow.

Lima proboscidia Sowerby, 1821, *Mineral Conchology*, vol. iii, p. 115, pl. cclxiv.

Holotype in Oxford University Museum.

Lima rudis Sowerby, *Mineral Conchology*, vol. iii, p. 25, pl. ccxiv, 1. (A misleading figure of an internal cast. See holotype in British Museum.)

Lima proboscidia Goldfuss, *Petrefacta Germaniae*, pl. ciii, 2.

Lima pectiniformis Blake & Hudleston, *Q.J.G.S.*, xxxiii, p. 292, etc. Non *Lima pectiniformis* Schlotheim; Non Morris & Lycett.

Lima rudis Sow., Blake & Hudleston, *Q.J.G.S.*, xxxiii, pp. 294, 295, etc.

Ctenostreon proboscidium Zittel, *Textbook of Palaeontology*, fig. 724 (English translation).

Diagnosis.—Shell large, broadly ovate, subequivalve, sub-orbicular obliquity scarcely appreciable. Escutcheon and ridge absent. Umbones depressed and not extending beyond the hinge line. Auricles large and prominent, particularly the posterior. Margin thrown into coarse irregular folds.

Surface ornament consists of twelve or fourteen coarse radial costae (twelve on the right valve, fourteen on the left), separated by regular intervals of about the same width. Each costa bears from one to three coarse tubular spines, thicker than the ribs from which they arise, and variously bent and twisted; some reach an inch in length.

The whole shell is covered by undulating concentric growth lines, which are less conspicuous on the ribs than in the intervening sulci. The undulations curve towards the umbo on the ribs and towards the margin in the sulci.

Dimensions of Holotype :—

Length.	Height.	Obliquity.	Inflation.	Number of ribs.
123 mm.	115	115	37½	12–14

Notes.—Morris and Lycett (*Great Oolite Mollusca*, p. 26) make *Ctenostreon proboscidium* a synonym of Schlotheim's *Lima pectiniformis*, which is a Dogger fossil. (See Zittel, *Textbook of Palaeontology*, p. 27). The shell from the Great Oolite figured by Morris and Lycett (pl. vi, 9) as *L. pectiniformis* Schlot. is narrower and has only nine ribs on the right valve, and is almost certainly a distinct species from the Corallian form. All references to *L. pectiniformis* in the Corallian refer to *Ctenostreon proboscidium* Sow.

Horizon and Localities.—Oxford Oolites and Coral Rag, from the Pebble Bed of Littleworth upwards. Particularly abundant in the Coral Rag. Sowerby's holotype was collected at Weymouth by Dr. Buckland of Oxford. It has a great deal of matrix attached, including *Serpulae*, *Exogyra nana* and a *Modiola* ; from the matrix it appears to have come from the Sandsfoot Grits.

LIST OF LIMAS RECORDED BY PAST WRITERS FROM THE CORALLIAN OF OXFORDSHIRE, BERKSHIRE AND WILTSHIRE, OMITTED FOR GOOD REASONS FROM THE PRESENT PAPER.

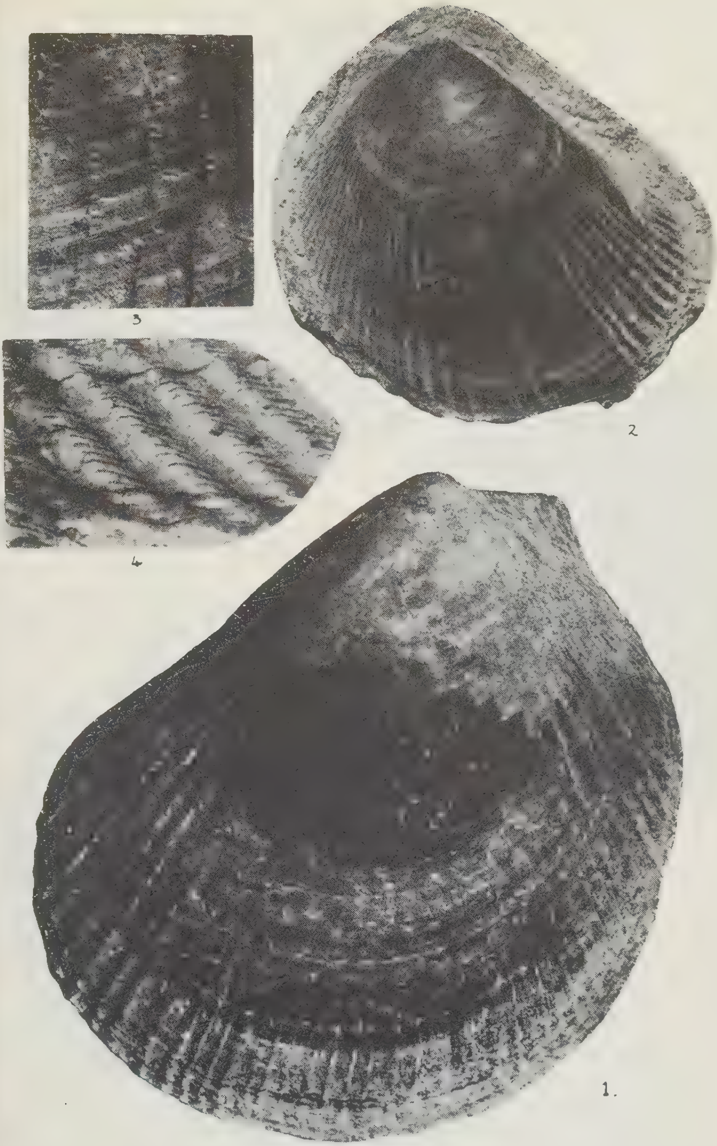
Lima densepunctata Roemer. Recorded by Blake & Hudleston from Westbrook, *Q.J.G.S.*, xxxiii, p. 289, and from Hillmarton, ibid., p. 292. I have little doubt that the species found was *Lima zonata*, of which there are three Westbrook specimens in Devizes Museum. *L. densepunctata* is a Portlandian species. (See Roemer, *Versteinerungen*, p. 79.)

Lima duplicata. Recorded by H. B. Woodward, *Jurassic Rocks of Britain*, vol. v, p. 115, from Tockenham, Wilts. The record probably refers to *Limatula elliptica* Whit. *L. duplicata* Sow. is probably confined to the Lower Jurassic. (See Morris & Lycett, *Great Oolite Mollusca*, p. 26.)

Lima pectiniformis Schlot. All references to this fossil probably refer to *Ctenostreon proboscidium* Sow. (which see).

Lima rudis Sow. Recorded in the lists of Whiteaves (1861) and Phillips (1871) and by Blake & Hudleston (1877), *Q.J.G.S.*, xxxiii, pp. 294, 295, from Catcombe and Purton. Examination of Sowerby's holotype in the British Museum shows that the figure in *Mineral Conchology* (vol. iii, pl. ccxiv, 1) is entirely misleading. The holotype, from Calne, is an internal cast of a right valve of *Ctenostreon proboscidium* Sow., the anterior part of which has been broken away. The consequence is that in the figure it appears much narrower than *C. proboscidium*, and appears to have only seven ribs. The umbonal region, however, shows indications of at least ten ribs. The projecting posterior auricle in Sowerby's figure is also misleading. It is in reality merely a part of the actual shell, left projecting beyond the internal cast which is all that remains of the umbones and the rest of the hinge line. There is no indication that if the shell were preserved it would differ in any way from a normal *Ctenostreon proboscidium*. The later records probably refer to young specimens of *Ctenostreon proboscidium*, which in the young state is more produced and devoid of spines.

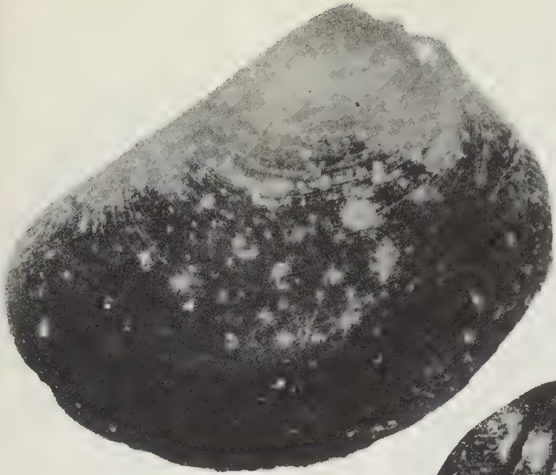
Two specimens from the Malton Oolite, labelled *Ctenostreon rudis*, in the Geological Survey Coll. (Nos. 43114, 43115) may be referable to a different species, since they are 25 per cent more produced than the holotype of *C. proboscidium*.



CORALLIAN LIMIDAE.

1–4. *Lima (Plagiostoma) laeviuscula* Sow.

[*To face p. 208.*



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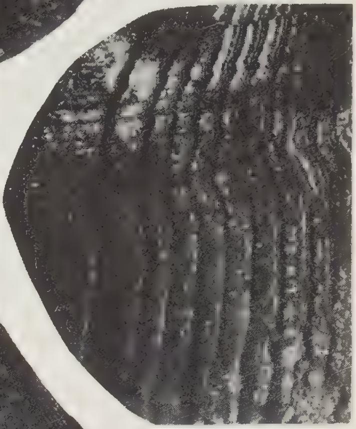

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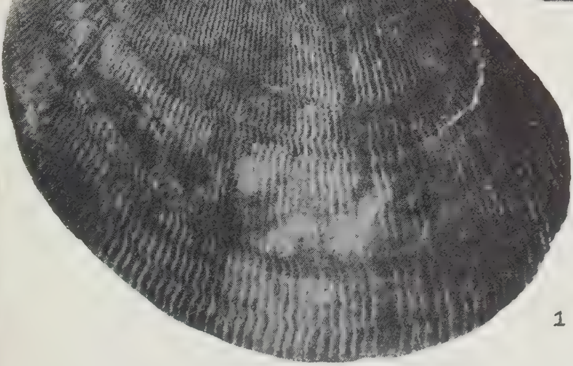

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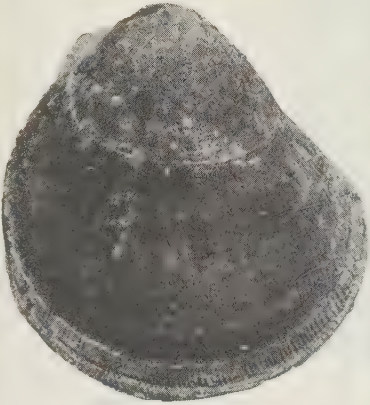
CORALLIAN LIMIDAE.

1–3. *Lima* (*Plagiostoma*) *mutabilis* nov.



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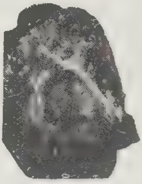

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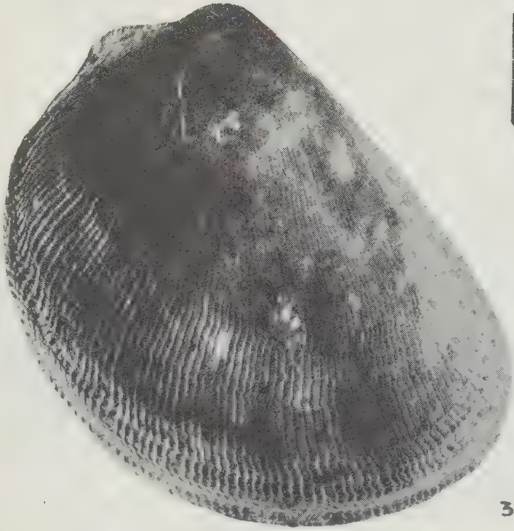
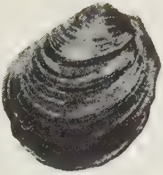


3.

CORALLIAN LIMIDAE.

1, 2. *Lima* (*Plagiostoma*) *rigida* Sow.
3. ,, ,, *highworthensis* nov.
4. ,, (*Limatula*) *elliptica* Whit.



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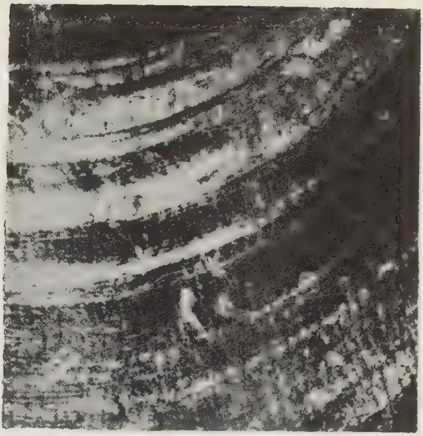

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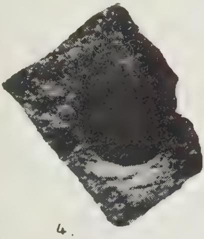

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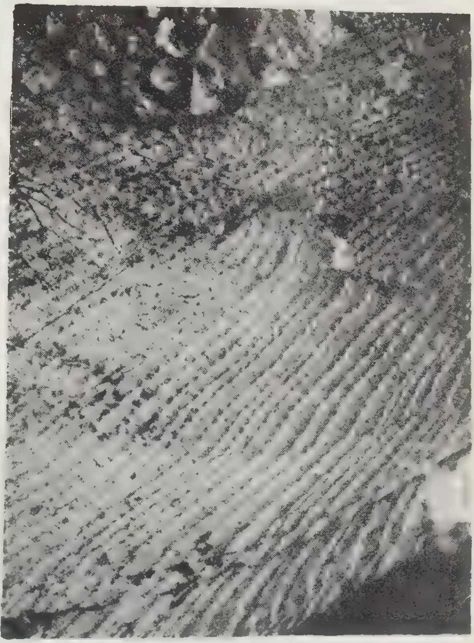

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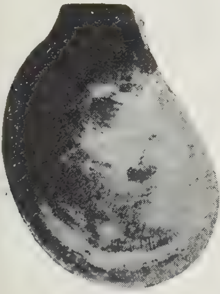

3

CORALLIAN LIMIDAE.

1, 2. *Lima (Plagiostoma) zonata* nov.
3–5. ,, *subantiquata* Roem.

Lima rustica Sow. Recorded in the lists of Whiteaves (1861) and Phillips (1871). Sowerby's holotype can be examined in the British Museum, and it is obvious that the matrix is the Kimmeridge-Portland of Shotover. Sowerby states " Found in clay mixed with sand, consisting of large green grains, upon Shotover Hill, near Oxford ". (*Min. Conch.*, vol. vi, p. 111.)

Lima semiornata Étall. Three internal casts of *Lima rigida* Sow. stood for many years in Oxford University Museum under this name.

Lima tumida Roemer. Three specimens of *Lima mutabilis* from Headington have been for many years exhibited in Oxford University Museum under this name, and have given rise to the general impression that *L. tumida* is the common *Lima* of the Oxford district. I have stated my reasons for disagreeing with this under *Lima mutabilis*, and here repeat my conviction that no punctate form comparable with Roemer's figure occurs in the district. *Lima tumida* Roem. is from the " Ober Coral Rag " associated with *Terebratula tetragona* (see *Versteinerungen*, p. 77), whereas all the species figured by Roemer which have been found in the English Corallian belong, without exception, to the " Unter Coral Rag ".

EXPLANATION OF PLATES XIX–XXII.

Plate XIX.

Fig.

1.—*Plagiostoma laeviuscula* Sow. British Museum Coll., No. 70464. Old age form with smooth sulci, practically devoid of punctae, resembling Sowerby's figures. Malton Oolite, Yorkshire.

2.—*P. laeviuscula* var. *grandis* Roem., British Museum Coll., No. 47456. Variety also showing sulci fading towards centre, as in *P. mutabilis*.

3.—*P. laeviuscula* var. *grandis* Roem. Ornament on umbonal region. Shell-cum-Pebble Bed, Headington. Oxford University Coll.

4.—*P. laeviuscula* var. *grandis* Roem. Ornament in marginal region. (Old age individual.) Shell-cum-Pebble Bed, Windmill Quarry, Headington. Oxford University Coll.

Plate XX.

1.—*Plagiostoma mutabilis* nov. Holotype. (var. *sulcatissima*.) Shell-cum-Pebble Bed, Magdalen Quarry, Headington. W. J. Arkell Coll.

2.—*Plagiostoma mutabilis* nov. var. *levis* nov. Shell-cum-Pebble Bed, Headington. Oxford University Coll.

3.—*Plagiostoma mutabilis* nov. Ornament about centre of shell, showing abrupt termination of sulci.

Plate XXI.

1.—*Plagiostoma rigida* Sow. Mature specimen. Trigonia-bed Limestones, Highworth. W. J. Arkell Coll.

2.—*Plagiostoma rigida* Sow. Ornament.

3.—*Plagiostoma highworthensis* nov. Holotype. Pendle or Nodular Rubble (= Coral Rag). Headington. Oxford University Coll.

4.—*Limatula elliptica* Whit. Mature specimen. Trigonia-bed Limestones, Highworth. W. J. Arkell Coll.

PLATE XXII.

1.—*Plagiostoma zonata* nov. Holotype. Geological Survey Coll, No. 43126. Mature individual. Coral Rag, Calne.

2.—*Plagiostoma zonata* nov. Ornament.

3.—*Lima* (*s.l.*) *subantiquata* Roem. Mature individual. British Museum Coll., No. 47455. Malton Oolite, Yorkshire.

4.—*Lima subantiquata* Roem. Young individual from the Urchin Marls, Shellingford, Berks. W. J. Arkell Coll.

5.—*Lima subantiquata* Roem. Ornament. Specimen from the Urchin Marls, Marcham, Berks. J. A. Douglas Coll.

Photographs by the author, E. J. Manly, and A. D. Passmore.

All but microphotographs about 0·78 natural size.

On the Probable Origin of the Members of the Bushveld Igneous Complex (Transvaal).

By C. G. S. SANDBERG, D.Sc.

THE Bushveld Igneous Complex lately formed the object of a study by the Shaler Memorial Fund Expedition and some members of the staff of the Geological Survey of South Africa, the principal object being to ascertain and fix its relation towards the upper division of the Waterberg Sedimentary System. Their report, published in the *Journal of Geology*,[1] would seem to furnish the necessary complementary data to fix the origin of the magmatic complex concerned, to a degree of extreme probability, as may be shown in the following.

No doubt prevailing about the Complex being the consolidated product of a magmatic eruptive occurrence (or of a succession of them) it seems appropriate briefly to recall my contentions about the origin of such active magmas and the consequent deductions I based thereon.[2]

In my publications cited below, I developed how I was brought to the acknowledgment of the *active magma* as the product of the liquefaction of sedimentary strata and the origin of mountain building and volcanism alike. Such magmatization would cause the lowermost strata to be transformed into a eutectic granitic mixture, whilst at lesser depth, that is with greater distance from the focus of excessively high temperatures, the various magmatic products of liquefied sedimentary strata would gradually affect, and more and more develop a distinct individuality according to, and in keeping with, the original constitutions of the respective sedimentary strata.

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[1] R. A. Daly and G. A. F. Molengraaff, "Structural relations of the Bushveld Igneous Complex, Transvaal," *Journ. of Geol.*, vol. xxxii, No. 1, 1924, pp. 1–35.

[2] C. G. S. Sandberg, "Geo-dynamische Probleme I and II," Gebr. Borntraeger, Berlin, 1924. Ibid., "Isostatic Tendencies as the origin of all Geodynamic Phenomena," GEOL. MAG., Vol. LXI, No. 725, Nov., 1924, pp. 482–93. See also W. Bowie, "Isostatic investigations and data for gravity stations in the U.S., etc.," Dept. of Commerce, Washington, ser. No. 246, 1924. Goldschmidt, *Stammestypen der Eruptivgesteine*. Vid. Skr. 1. Mat. Nat. Kl. 1922, No. 10, Kristiania. E. Haug, *Traité de Géologie*, Arm. Colin, 1907.

Such tendencies to individualization of the various products of magmatization, accentuated by decrease of temperature (entailing decrease of fluidity, i.e. mobility) would seem a natural inherent faculty of magma, its enclosed condition, its high degree of viscosity, and the relatively small differences of specific gravity between its various components of liquefied sedimentary deposits, constituting impediments to any tendency of motion and mixing which might be present or generated in the magma body.

From a eutectic mixture of granitic composition in the lowermost regions of the magmatic body, we may thus expect its upper parts to consist of layers, more sharply defined as they are situated at greater distance from the lower regions of total granitification. Simultaneously the various components of the active magma will tend to betray more and more the nature of the sedimentary substance they originate from. It follows that, whilst we may expect rocks of typical intermediate composition in the boundary regions of two adjacent or superposing components of different constitution, situated in the lower parts of the individualized zone, such may be little or not at all developed in the parts of the zone nearer to or at the periphery of the magmatic body.

Let us now return to the area of the Bushveld Igneous Complex. A copy of the Shaler Memorial Expedition's geological map, reproduced in Fig. 1, shows the main components of the complex, the Red Granite in the centre, and the Norite surrounding it, to be remarkably concentrically arranged.

The geological literature on the occurrence shows that the components of the complex extend in sheets or layers[1] affecting, in their upper portions, a well-developed platy or pseudo-stratified structure.[2]

Besides the main components of the complex shown on the map, Fig. 1, we find that " closely associated with the Norites are widely extended, sheet-like bodies of granophyre and felsite, *which are chiefly developed within the outer boundary of the norite* ".[3] . . . " Several observers have reported apparent transition from the felsite to granophyre. In Sekukuniland at least, the granophyre is dyked by apophyses from the great Norite body, *though* [I should have said ' *and* '] the apophyses are generally quartzose and more silicious than Norite. Hall has concluded that elsewhere the Norite is transitional into granophyre . . ." ((3) p. 19).

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[1] G. A. F. Molengraaff, " Esquisse géologique de la République Sud-Africaine du Transvaal," *Bull. Soc. Géol. de Fr.*, 4e Série, T. I, 1901 (also German translation).

[2] E. T. Mellor, " Report on Portions of the Pretoria and Middelburg Districts etc.," *Ann. Report Geol. Surv. Transvaal*, 1903 (Pretoria, 1904), pp. 7–37, a.o.

[3] R. R. Daly and G. A. F. Molengraaff, loc. cit., p. 2. The italics are mine.

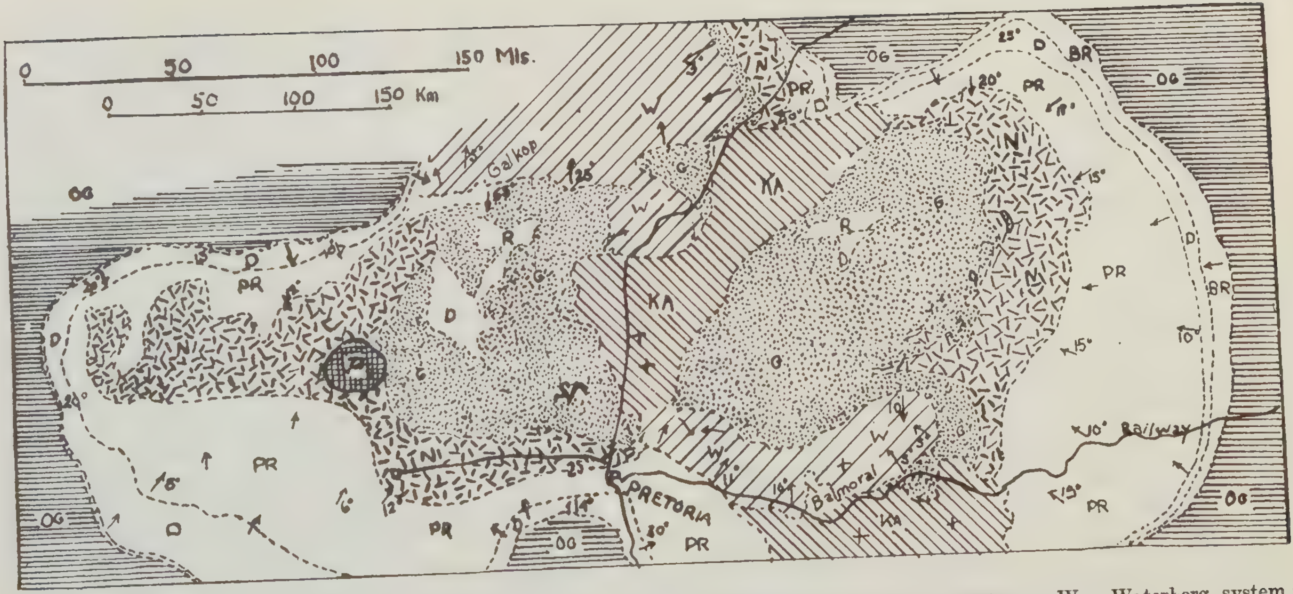

FIG. 1.—Map of the Bushveld Igneous Complex, after Daly and Molengraaf. KA = Karroo system; W = Waterberg system; G = Felsite, granophyre and granite of the Bushveld complex; N = Norite (pyroxenite, anorthosite, etc.) of the Bushveld complex; PR = Pretoria quartzite and shales; D = Dolomite; BR = Blackreef quartzites; OG = Old Granite; P = Alkaline rocks; SP = Salt Pan caldera.

As to the inner boundary of the Norite, i.e. the one between Norite and Red Granite, Molengraaff established [1] that " types of intermediate acidity are formed, such as syenites, nepheline-syenites, etc."

Finally Mellor mentions,[2] that " Coincident with the transition from the massive structure [in the centre] [3] of the deeper portions of the laccolith to the platy structure of its upper portions, is a gradual change petrographically from the typical coarsely crystalline granite to a rock consisting mainly of abundant quartz grains in a close felsitic ground mass, and containing very little ferromagnesian material."

Summarizing, we can thus establish the following succession of sheet-like superposing eruptive rocks, composing together the Bushveld Igneous Complex :—

Felsites.
Granophyre.
Transitionary rocks.
Norites.
Syenites, etc. (transitionary rocks).
Acid Red Granite (poor in Fe–Mg material ; platy).
Red Granite of massive structure.

The latter, situated in the centre of the area, forms the top layer. One group of rocks I did not mention in the above list, viz. the Granophyre-felsites, connected with the Red Granite, their exact relative position with regard to the other members of the igneous complex not being given anywhere. The expedition's report also, is rather vague on this point. From what I could gather, it would seem that they represent the two successive phases of the acid Red Granite in its consolidation process at the time of and subsequent to its extrusion ; the felsite representing the upper part and consequently more rapidly chilled phase of the magma.

This igneous complex rests on a subsided sedimentary floor, which itself is supported by the so-called " Old or Grey Granite," composed of the following strata (from top to bottom).

Pretoria Series	Magaliesberg quartzites Shales Dasport quartzites Shales Timeball Hill quartzites Shales, sandstones, and conglomerates.

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[1] G. A. F. Molengraaff, " On the deposits of iron ore in the Transvaal,". *Trans. Int. Geol. Congress Stockholm,* 1910, pp. 1057–62. Ibid., loc. cit. (1), p. 53.

[2] E. Haug, *Traité de Géologie.* Arm. Colin, Paris, 1907. C. G. S. Sandberg, loc. cit. (2).

[3] The bracketed remark is mine.

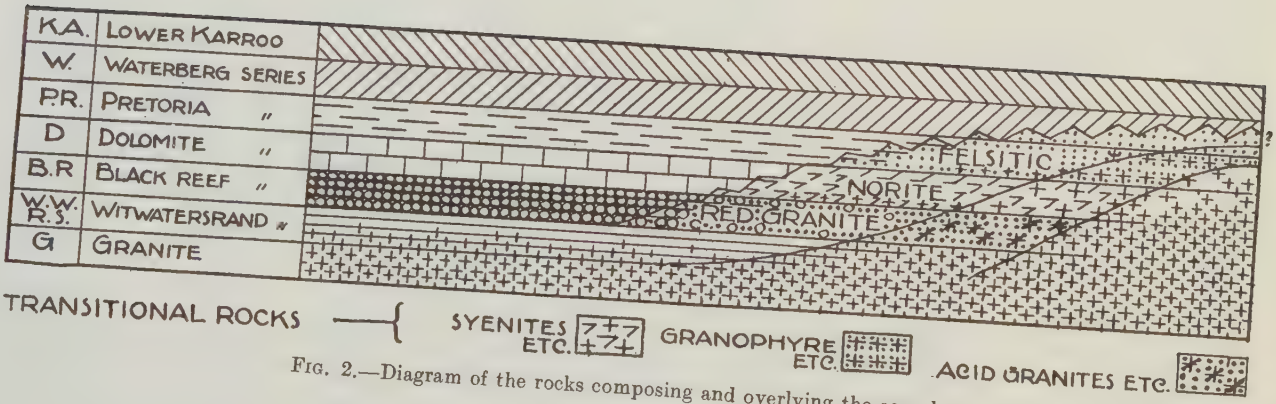

Fig. 2.—Diagram of the rocks composing and overlying the complex.

Banded iron-ore in boundary zone.

Dolomite Series	Layers of dolomite, chert, and shales in alternate repetition.
Black Reef Series	Quartzites, arkoses, shales, and basal conglomerate.

OLD OR GREY GRANITE.

Supposing now that in the ordinary course of sedimentation in a geosynclinal, such complex, together with its normal granite substratum extending over a vast area, were covered by younger sedimentary deposits weighing it down and bending it so that parts of it were brought into the zone of liquefication and magmatization.

We may then expect the following equivalent magmatic, eruptive rocks to result respectively (Fig. 2).[1]

The Old Granite substratum, consisting of a normal granitic substance, while remaining practically unaltered in its lower, deeper regions, would acidify in its zone of contact with the overlying highly siliceous Black Reef deposits. We may well expect a more acid granite, similar to the Red Granite of the central part of the Bushveld Igneous complex to result, differing in places but little from the Old Granite.

Higher up, i.e. above the zone of contact, the aluminous, highly siliceous deposits of the Black Reef Series, liquefying and recrystallizing would assume the habitus of a quartz-felspar granitic rock very poor in Fe-Mg elements,[2] such as actually described by E. T. Mellor,[3] between the central part of the B.I. complex and its surrounding Norite.

The next sedimentary deposit, covering the Black Reef Series, i.e. the Dolomite Series, may be expected to have been converted into an equivalent magmatic rock of great basicity[4] such as Norite, with ultra-basic "segregations" of iron-ore, *which latter happen to occur at the same horizon as they are met with in the unaltered Dolomite Series*, i.e. in the boundary zone between these and the Pretoria Series.[5]

As to the lower boundary region, between the Norite (converted Dolomite) and the acid Red Granite (converted Black Reef) we should expect eruptive rock of intermediate acidity to occur, should our contentions be correct. In fact, Molengraaff,[6] established the presence of such rocks, Syenites, Nepheline Syenites, etc., in this very boundary zone.

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[1] E. Haug, *Traité de Géologie*; C. G. S. Sandberg, *Geo-dynamische Probleme.*

[2] In Fig. 2 opposite this rock is marked Red Granite.

[3] E. T. Mellor, loc. cit.

[4] R. A. Daly, "The Genesis of Alkaline Rocks," *Journ. of Geol.*, vol. xxvi, No. 2, 1918, pp. 97–134. M. Lugeon and Oulianoff, *Sur la Géologie du Massif de la Croix de Fer. C. R. Ac. Sc. Paris*, t. 171, pp. 563–5, 1920.

[5] P. A. Wagner, "Report on the Crocodile River Iron Deposits," *Geol. Surv. Mem.*, No. 17, 1921 (Dept. of Mines, S. Africa).

[6] G. A. F. Molengraffe, "On the Deposits of Iron-Ore, etc.," loc. cit.

A magmatization of the silico-aluminous Pretoria Series, covering the Dolomite, as such very much comparable with the Black Reef Series, underlying the Dolomites, may consequently be expected to result in an acid granitic type bearing great affinity to the acid Red Granite. Yet the increased distance from the focus of total granitification in depth, would entail decrease of temperature and consequently less perfect recrystallization.

In fact, we actually find the Granophyre and then the Felsite widely developed in sheets along the outer boundary of the Norite.

Should the magmatizing energy be sufficiently efficient still in this outer zone, then we may expect to find some evidence of tendencies to the formation of transitional types of rock between the Norite and the Granophyre, as Hall evidently did.

It seems evident, however, that the magmatization energy is at or near the limit of its transforming power, and we should therefore not be surprised by a scarcity or even absence of any typical evidence of its action in any younger strata (Waterberg Series ?) which might have covered the upper Pretoria Series. For the same reason typical rock of intermediate acidity might have been lacking or very scarce in the boundary zone between Norites and Granophyres. Yet close study, petrographical and chemical, might (and most likely will) disclose here also, the presence of transitional rocks to be a feature far more regularly developed than hitherto established, the more so, because transitional zones in the sedimentary deposits between the Dolomite and overlying Pretoria Series have been established,[1] sometimes showing a highly metamorphosed condition already.

In Fig. 2 and Fig. 3*a* a diagrammatic representation of the results of such magmatization is given schematically, the intensity of transformation diminishing, radially, in direct relation to the distance of the centre of the magmatizing energy (right bottom corner of Fig. 2), i.e. in general from right to left, for each of the various strata concerned, and as a whole, from below upwards.

Summarizing, we have shown that the Bushveld Igneous Complex is composed of a series of magmatic equivalents of the members of the adjacent Pretoria System, which is partly covered by the eruptive complex. Moreover, that the order of succession of the various members of the sedimentary system corresponds exactly with that of the various members of the B.I. complex. To this we might have added that even the physical structures of the sedimentary-eruptive complexes preserved in the higher parts of the latter, show a remarkable similarity to each other. I am alluding to the pronounced divisional, platy, flaggy, and banded structures so characteristic of the several members of the sedimentary system, which we find again in the higher parts of the various members of the B.I. complex.

The question now arises whether we may regard this close series of coincidences as merely accidental, as the result of a freak of nature, or whether we have to acknowledge it to be due to result of a mutual relation of the sedimentary deposit and respective eruptive rock, to one of cause and effect which developed under the influence of deep-seated energies.

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[1] P. A. Wagner, loc. cit.

The well-established facts before us do not seem to allow of a doubtful reply, and consequently the sedimentary-eruptive area of the Bushveld would constitute, in its simplest form, a most striking and grand example of individualized magmatization of sedimentary strata and the *mise-en-place* of its products by magmacratic energy.

If now this contention be correct, the mechanism of such *mise-en-place* would also seem self-evident.

Part of the Transvaal System and its substratum having been brought within the zone of rock-liquefaction, subsequent to prolonged sedimentation and sedimentary accumulation of younger deposits, would magmatize its various members, transforming them according to their original constitutions and preserving their individuality nearly complete.

Under the influence of high gas- and vapour-tensions the active magma thus generated would tend to relief of pressure in the direction of least resistance. Such tendency would cause the magma to lift its cover of younger deposits, creating a discontinuity between these and the underlying Pretoria Series, because of the magmatization process not having continued beyond the boundary plane between these series and the younger Waterberg System.[1] Lifting its roof and simultaneously disjointing the strata of the Transvaal system all round the rising magma, the igneous material would force itself in laccolithic fashion between the Waterberg roof and the subjacent Pretoria Series.

We may readily conceive the various members of the igneous complex thus gradually developing in concentric order and mushrooming over the Pretoria Series under the weight of the Waterberg (and younger ?) Series, the Red Granite occupying the central part, the felsites on the periphery. A schematic representation of such mechanism is given in the block-sections, drawn in an E.–W. direction over the area (*e* and *f* respectively north and south of the Salt Pan). The petrographical legend of the principal members of the igneous complex corresponds with that given in Fig. 2 (p. 214).

Simultaneously, the disjointed Pretoria Series would afford an easy access to intensely active metamorphosing agents of the high-tension magma and its more mobile basic matter, facilitating its injection between the strata.

Gradually developing towards its paroxysmal phase, the final

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[1] The unconformity between the two successive systems would also favour this process.

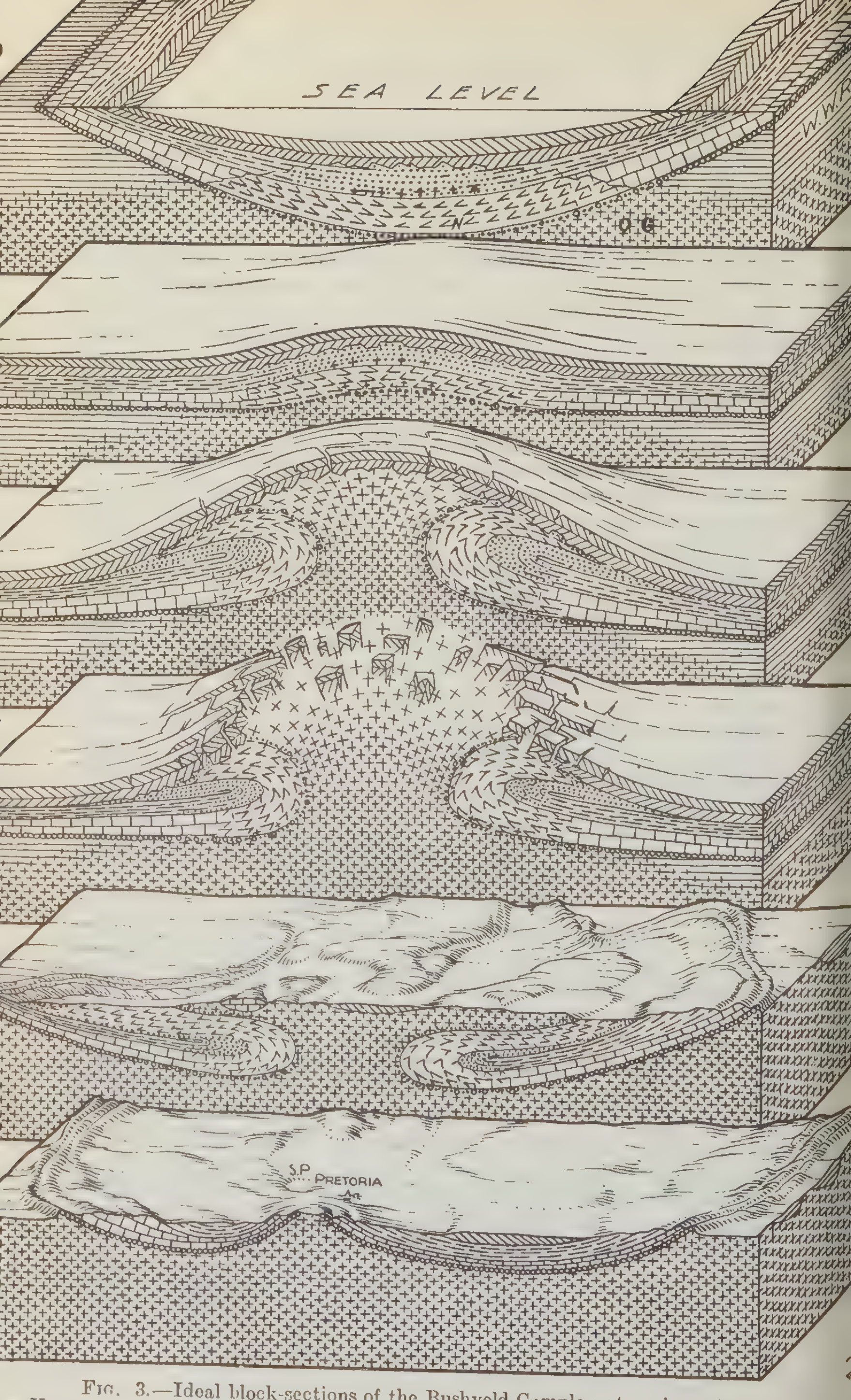

FIG. 3.—Ideal block-sections of the Bushveld Complex at various stages.
= Karroo System ; P.R. = Pretoria Series ; D. = Dolomite Series ; W.W.R.S. = Witwaters
System (?) ; O.G. = Old granite.

act, in blowing up the roof, scattering its fragments and possibly causing the de-vapourated substratum to be weighed down by the burden of the ejected solid material, would disclose the Igneous Complex with all its characteristic features as we know it to-day, with some huge blocks of undigested sedimentary material, too heavy to have been hurled beyond the zone of igneous extrusion, and others floating in the igneous mass in tattered strips, the remnants of the erstwhile roof still covering it here and there.

Note on the Relation of the Upper and Lower Old Red Sandstone of Gower.

By Daisy M. Williams, M.Sc., University College, Swansea.

THE Old Red Sandstone occurs in Gower in several inliers which form hills rising above the undulating plateau of Carboniferous Limestone. The chief are Cefn-y-bryn (548 feet) in mid-Gower, Llanmadog Hill (609 feet), the westerly extension of Cefn-y-bryn in north-west Gower, and Rhosilli Down (633 feet) in the extreme west of Gower.

The following is the succession of Old Red Sandstone as represented in Gower, compared with the fuller development in the Brecknock Beacons :—

GOWER.[1]

	Feet.
White Conglomerate	130–160
Red Conglomerate	90–160
Brownstones	(?) 100–700
Senni Beds	absent
Red Marls	0–300

BRECKNOCK BEACONS.[2]

		Feet.
Grey Grits and Conglomerates		0–200
Brownstones with Plateau Beds		1400–1500
Senni Beds	probably	1000
Red Marls	about	4000

The Red Marls have been proved to represent the Lower Old Red Sandstone,[3] while the Brownstones in other parts of South Wales have been proved to belong to the Upper Old Red Sandstone. The Senni Beds which form the upper part of the Lower Old Red Sandstone along the north crop of the South Wales coalfield, were not recognized by the officers of the Geological Survey to the south of the coalfield, either in Gower or in the Cardiff area. Mr. R. Davies and Dr. A. Heard[1] suggest that the upper portion of the Red Marl in the Cardiff district, which contains thin bands of pale green sandstones may represent the Senni Beds " as there is no evidence to suggest that the Senni Beds are not represented on the South crop ".

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[1] "The Geology of the South Wales Coalfield," part ix, "West Gower and the Country around Pembrey," pp. 4, 5, 1907, *Mem. Geol. Surv.* This work is referred to subsequently as the "West Gower Memoir".

[2] "The Geology of the South Wales Coalfield," part v, "The Country around Merthyr Tydfil," 1904, *Mem. Geol. Surv.*

[3] "West Gower Memoir," p. 5.

In Gower the Red Marls are seen in one locality only, namely, on the western face of Rhosilli Down, where they are at least 300 feet thick, and they are immediately overlain by about 700 feet of Brownstones. Nearly 3½ miles east of Rhosilli, in the western end of the Cefn-y-bryn inlier, a thin development of Brownstones rests directly on the Silurian, while 3 miles further east in the same inlier the Brownstones appear to be almost overlapped by the Conglomerate. The officers of the Geological Survey suggest that the Brownstones are unconformable to the Red Marls ;[2] evidence of this unconformity was obtained in several areas in Pembrokeshire,[3] but the unconformable junction there is never more than slightly irregular.

In Glamorgan, however, an unconformable junction does not appear to have been noticed. The object of this note is to record the fact that in Gower there is distinct evidence of discordance between the Brownstones and Red Marls (or Senni Beds if represented) and also to draw attention to the importance of the Old Red Sandstone of Gower in any discussion of the relations of the Old Red Sandstone of South Wales and the Devonian of Devon.

The local strike of the Old Red Sandstone in Rhosilli Down is nearly north-south with a dip of 30° east. The eastern side of the ridge is a dip slope of the Conglomerate ; the western is a scarp of the Conglomerate and Brownstones underlain by the Red Marl. The exposure showing the junction of the Brownstones and Red Marl is to be seen towards the northern end of the hill, half a mile north of Rhosilli rectory, and about 200 feet above the path running at the foot of the hill. The accompanying diagram illustrates the nature of the junction (Fig. 1).[4]

At the northern end of the exposure the base of the Brownstones rests directly on a cornstone band which yielded to the Geological Survey officers the remains of a pteraspid fish ; in the south, however, the two are separated by red marl which increases in thickness as it is traced to the southern end of the exposure. At the base of the Brownstones is a conglomerate with pebbles of red and more rarely green marl up to 2 inches long, and a coarse sandy matrix. These pebbles of red marl are to be found to a distance of about 3 feet above the base of the Brownstones, but within this thickness they are not regularly distributed and tend to form several bands separated by coarse sandstones.

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[1] " The Old Red Sandstone of the Cardiff District," *Q.J.G.S.*, vol. lxxx, 1924, p. 496.

[2] " West Gower Memoir," p. 6.

[3] " The Geology of the South Wales Coalfield " ; pt. xiii, " The Country around Pembroke and Tenby," 1921, pp. 27, 28 ; pt. xi, " The Country around Haverfordwest," *Mem. Geol. Surv.*, pp. 123, 124, 136, 204, 1914.

[4] Certain bands within the Lower Old Red Sandstone of Pembrokeshire frequently show evidence of contemporaneous erosion, but there does not appear to be evidence of such discordant junctions within the Red Marl of South Glamorgan.

The importance of the evidence of an unconformity within the Old Red Sandstone of South Wales and especially of the overstep of the Brownstones, has been recognized by several workers; in particular the late A. J. Jukes-Browne[1] emphasized its significance in discussing the conditions of deposition of the Devonian and Old Red Sandstone. He regarded it as indicating the existence of a ridge and thus supporting the hypothesis of a " Welsh Lake ". At the same time he pointed out that the "land barrier between it and the Devonian Sea must have been very narrow for the distance between the cornstone outcrop near Cowbridge and the north coast of Devon, where the beds are marine, is only 17 miles ".[2]

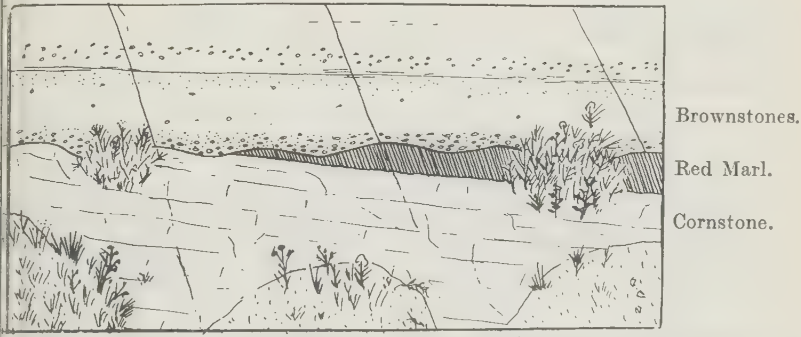

FIG. 1.—Diagram to illustrate the unconformable junction of Brownstones and Red Marl in Rhosilli Down, Gower. Scale: 1 in. = 6 ft.

Professor L. Dudley Stamp[3] in discussing the origin of the Old Red Sandstone has accepted this evidence for the existence of a lake in South Wales, and he asserts that " in the South, the most marked effect of the movements (Siluro-Devonian) was the formation of an east-west ridge from South Wales, probably under the London District to Belgium ", which divided the area of marine accumulation from the area of continental deposits.

Recently the Welsh Lake theory has been criticized by Dr. J. W. Evans[4] who regards the Old Red Sandstone of South Wales as a continuation northwards of the Devonian deposits of Cornwall and Devon. According to his view, the Devonian rocks in North Devon represent an alternation of continental and marine sediments, and indicate that the position of the shore line changed repeatedly during this period. The shore line, however, does not appear to have moved as far north as the present coast line of Glamorgan, as there is no evidence of a marine facies in the Old Red Sandstone of Glamorgan, though such exists in the Upper Old Red Sandstone of Pembrokeshire.[1] Dr. Evans regards the land barrier which is a necessary condition for the existence of a Welsh Lake, as too narrow to have supplied the material for the Devonian of North Devon; but in considering this explanation of the geography of the Devonian and Old Red Sandstone times, it is important to remember, as Dr. Evans himself notes that "the distance between any two points and their orientation relatively to one another, have varied in a very considerable degree in the course of geological time."[2] Certainly all north-south distances in South Wales need increasing in any ultimate attempt at restoration of Devonian geography.

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[1] *The Building of the British Isles*, 1911, p. 128.

[2] Op. cit., p. 128.

[3] *An Introduction to Stratigraphy (British Isles)*, 1923, p. 95.

[4] " The Geological Structure of the Country around Combe Martin " : *Proc. Geol. Assoc.*, vol. xxxiii, pt. iii, 1922 ; GEOL. MAG., Vol. LX, 1923, p. 394.

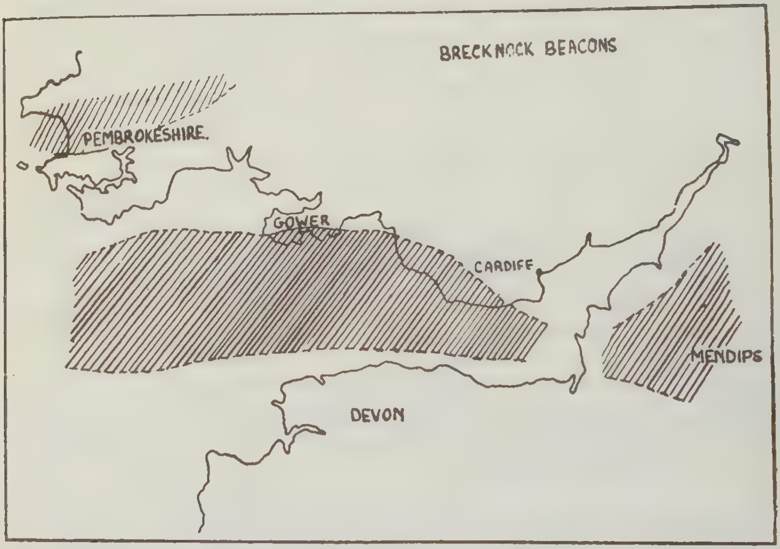

FIG. 2.—A suggested restoration of the geography of Lower Old Red Sandstone time in South Wales and North Devon. Scale: ·032 in. = 1 mile.

The Gower evidence, namely the absence of Red Marl on Cefn-y-bryn and the overstep of the Brownstones on to Silurian rocks, supports the suggestion that land existed in this area during Lower Old Red Sandstone time. How far this land barrier stretched to the east is unknown, but possibly it was not connected with the land which existed in the Mendip area during this period, since the lower Marls attain a thickness of 2,800 feet near Cardiff. The total thickness of the Old Red Sandstone deposits in the Brecknock Beacons (about 8,000 feet) and in North Devon [1] (about 20,000 feet) when compared with the thickness developed between these two areas (Gower a maximum of about 1,300 feet and Cardiff 3,500 feet) suggests that there were two basins of deposition, one to the north and one to the south of the "Gower-Mendip line"; the overlapping and overstepping seen in the Old Red Sandstone of Gower show that the belt between these basins underwent more gradual submergence, interrupted by at least one period of elevation.

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[1] "The Geology of the South Wales Coalfield," part xiii. "The Country around Pembroke and Tenby," 1921: *Mem. Geol. Surv.*, p. 26.

[2] "The geological structure of the country around Combe Martin, North Devon": *Proc. Geol. Assoc.*, vol. xxxiii, pt. iii, 1922, p. 223.

Possibly the two basins were never completely separated, and at certain times the barrier was perhaps of small extent, but it appears at least probable that there was not complete connexion between the two areas for the greater part of Devonian time.

The Evishanoran "Esker", Tyrone.

By J. Kaye Charlesworth, D.Sc., Ph.D.

In his fair and courteous paper on the Evishanoran Esker, Tyrone, which appeared in the October issue of this Magazine (p. 451), Professor J. W. Gregory finds himself unable to accept the writer's view of the origin of this glacial feature and re-states at greater length the theory he had earlier formed.[2] Though the area under discussion is very small—only one or two of the 4,000 sq. miles described in my paper on the Glacial Geology of the north-west of Ireland [3]—the importance of the principles involved in this disagreement of views necessitates a reply, however brief, to the criticisms of my interpretation to which I still unrepentently adhere.

In the opinion of Professor Gregory, the esker, or the moraine as I prefer to call it, was formed by local glaciers centred in the relatively low hills to the east, whereas in my view it was laid down by powerful and extraneous ice which lay to the west and south-west and continuous with the great ice-masses of Donegal and the north-west of Ireland. The question at issue is, therefore, on which side of the moraine did the ice lie?

Professor Gregory bases his interpretation firstly upon the composition of the moraine, which he asserts is indicative of a southern origin. Into the details of the composition it is unnecessary to follow him, especially as practically all his data, and more, were embodied in my earlier paper in its unabridged form prior to publication. I still insist, therefore, as no new evidence has come to light, that this composition is reconcilable with the direction of ice-flow from the south-west which I earlier postulated and with that mode of origin of this moraine which I have previously maintained.

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[1] J. W. Evans, op. cit., p. 204.

[2] *Phil. Trans. Roy. Soc.*, ccx, 1920, pp. 115–51.

[3] *Proc. Roy. Irish Acad.*, xxxvi, 1924, pp. 174–314.

The second support for his view Professor Gregory sees in " the fact that the curves of its [esker or moraine] course are concave to the south-east ". But are they ? An impartial inspection of Professor Gregory's own map (p. 457) would reveal a fairly straight course with minor concavities to the east counterbalanced by equally poor or good concavities to the west. Such sinuousities as do occur are, however, significant, though I submit, in a totally different sense from what Professor Gregory believes ; the concavities are directed to the west across the valleys, e.g. at Dunnamore between the heights of Slievemore and Evishbrack Mountain, and again about 1 mile south south-east of Broughderg Bridge (cf. Professor Gregory's map, p. 457), and to the east along the flanks of the hills, e.g. Hill 749, Evishbrack Mountain and Slievemore. This I maintained, and still maintain, is proof of ice-pressure from the west and south-west against the sides of the hills and of the invasion of the intervening valleys by small lobes of ice thrust into them from these directions. " The curving course of the Dunnamore and Davagh Eskers around the Beleevnamore range " which Professor Gregory regards as indicating " the transport of their material down the western and north-western slopes of that range " is clearly equally compatible with the presence of extraneous ice to the west, moulded on to the contours of the hills as is here suggested.

This view is, I think, further borne out by the fact, recognized by Professor Gregory (p. 458), that the moraine rises steeply towards the southern end of its course, which implies an ice-flow from this direction and a falling of the ice-edge toward the north, a conclusion which is supported by the occasional swinging out of other ridges in tangential form with the concavity to the west and south-west (cf. the branch running north from L. Doo, map, p. 453).

Furthermore if, as Professor Gregory suggests, these moraines were deposited by local glaciers streaming westward down the slopes of the hills, how is the course of the moraine across the depressions to be explained where its development is equally good ?

The sharp limitation of the esker drift to the west and north-west which Professor Gregory relies upon as a third reason for his belief is, in so far as it is a correct observation of the facts—and the flat moorland bogs conceal much of the underlying drift—but another proof of the presence of an ice-contact slope to the west and south-west.

As I have earlier set out,[1] though Professor Gregory makes no reply to it in his paper, the most important difficulty, to my mind, encountered by his view is the impossibility of its reconciliation with the movements and behaviour of the ice in the adjacent and surrounding areas.

The cols of the main watershed of the Sperrin Mountains, which lie only some 6 miles to the north of the area under discussion, were gashed at heights ranging between 1,000 and 1,350 feet O.D. by the drainage from the margin of the extraneous ice retreating *down* the hillsides towards the south and south-west.

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[1] Op. cit., p. 263.

Again, the magnificent channels discovered on the flanks of Slieve Gallion, about 4 miles to the north-east, by Dr. A. R. Dwerryhouse and myself in a week's conjoint field work and described by one of us,[1] demonstrated beyond all shadow of doubt the presence of a powerful mass of foreign or non-local ice likewise withdrawing *down* the flanks of the hill and in a westward and south-westward direction. The summit of Slieve Gallion is 1,735 feet. O.D.

In the face of this apparently incontrovertible evidence, Professor Gregory asserts as his main thesis that low conical hills, culminating in heights of only 886 and 749 feet, devoid of corries or catchment basins, rising only about 200 or 300 feet above the moorland peneplain, stretching northward to the Sperrins and north-eastward to Slieve Gallion, could at the same time as these events were taking place, produce glaciers exceeding a mile in length !

Glacial orographical snow-lines were doubtless highly irregular at times, but such irregularity as Professor Gregory's conclusions would lead us to infer would baffle the most valiant attempts at solution.

In fine, the composition of the moraine, its course, curving into and across the depressions and clinging in slightly bent arcs to the hillside, its ascent to the south or south-west, together with the movements and behaviour of the ice in the surrounding areas, prove that the Evishanoran " Esker ", like numerous features of similar form and origin in the adjacent regions, was formed along the margin of a powerful mass of extraneous ice retreating in a westward and south-westward direction and in continuity with the ice-masses of Donegal and north-west Ireland.

In conclusion, I would with diffidence observe that this honest disagreement in interpretation of the origin of the Evishanoran " Esker " has at its roots a difference in the mode of attack. In glacial studies, as in most others, it would seem to be increasingly advisable, if the whole truth is to be obtained, to secure wider views by the study of larger areas and so ensure the elimination of those errors, some times of little moment, other times of vital and fundamental importance, which more local studies would seem almost inevitably to produce. Though in reply it may truthfully be urged that the part cannot be inconsistent with the whole, yet when so many factors have to be considered (including in this case the glaciation of the region at successive periods by ice flowing from different directions), capable of sustaining more than one interpretation, the conclusive answer can only be forthcoming when the relation of the parts to the whole have been considered or when wider studies have been carried out.

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[1] A. R. Dwerryhouse, *Quart. Journ. Geol. Soc.*, lxxix, 1923, p. 376.

REVIEWS.

EVOLUTION. By Professor J. GRAHAM KERR, F.R.S. Pp. xii + 278; two coloured plates and 53 text-figures. London: Macmillan and Co., Ltd., 1926. Price 12*s*. net.

THE standpoint of the author of this book is essentially that of a Darwinian. He has no doubts as to the potency of natural selection as the main factor in evolutionary change, and while accepting variability as a basal fact he believes that it is promoted and fostered by natural selection. Darwin's supplementary theory of sexual selection is likewise accepted, but in the author's view there is no justification for regarding the transmission of acquired characters as a contributory factor to organic evolution. The first part of the book consists of a presentation of some of the main evidence of evolution and in the general treatment of the subject recalls the works of Herbert Spencer and G. J. Romanes, written nearly half a century ago. Starting with the argument from embryology, the author passes on to the evidence supplied by palaeontology, comparative anatomy, and geographical distribution. Most of this evidence has long since been accepted as uncontrovertible, but in the chapter on palaeontology there are some statements to which exception must be taken. Thus, on p. 26 we read: "Do these rocky deposits provide us with a continuous record from the commencement to the end of the period of time which they represent? Quite the contrary!" And, again, "the various chapters of the Geological Record, the various formations as geologists call them, are not continuous with one another, but are spaced out by intervening gaps representing vast, although quite indeterminate, periods of geological time." Neither of these statements is strictly correct, for there is evidence that the marine deposits of the world, if taken together, do actually represent unbroken continuity, and that where there are gaps in the terrestrial stratigraphy, these are regional, and do not extend throughout the earth, that is to say there are reasons for supposing that every period in geological history from Cambrian times onwards is represented by rocky deposits somewhere on the face of the globe.

Professor Graham Kerr is at his best when he writes as a field naturalist, and for the chapter on adaptation we have nothing but praise. The other parts of the book are not beyond criticism; for example, the determination of sex is not the simple matter of chromosome division that the author implies—this is shown by the many instances of sex reversal, both natural and experimental—but we have no space to go into this question here. The worst chapter is that on "Evolution and Man", in which Professor Kerr appears to advocate unrestricted propagation with a view to providing natural selection with unlimited material on which to work and to the end that progress may be maintained.

We cannot conclude without a word of praise for the coloured plates and text-figures, but that of the spermatozoon on page 12 is quite unlike the normal appearance of these organisms as seen under the microscope.

F. H. A. M.

THE OSTEOLOGY OF THE REPTILES. By the late Professor S. W. WILLISTON. Arranged and edited by Dr. W. K. GREGORY. pp. xiii + 300; 191 figures in text. Harvard University Press; and London and Oxford, Humphrey Milford, 1925. Price 18*s.* 6*d.* net.

THIS book embodies the main results of fifty years of the late author's working life. Most of it was finished in 1918, when Professor Williston died, leaving others to complete his task. The delay in publication is only partially explained by the editor, but we are told that the difficulties were eventually overcome by the good offices of Professor Barbour and the Harvard University Press. The result is a matter for congratulation. The book has been brought up to date by the editor, assisted by other specialists, the new matter being inserted in square brackets and often in the form of footnotes. Many of these are contributed by Dr. G. K Noble of the American Natural History Museum. It has thus been possible to include references to the more striking recent discoveries, such as Watson's important identification of the quadratojugal bone in the Anomodontia. The first part of the work, comprising two-thirds of the whole, is devoted to a general account of the reptilian skeleton, the different parts being dealt with in successive chapters. The second part, consisting of the last hundred pages, treats of the classification and range of reptiles and starts with a chapter on the problem of classification, this being followed by a general systematic account of the various orders. Most genera are included, but there are some omissions, notably among the tortoises. A word of praise must be added for the admirable series of line drawings prepared by the author for this work. These are supplemented by further illustrations taken mostly from Williston's earlier books, but a few of the figures are borrowed from other authorities. It is to be regretted that the references to literature are so scanty and that there is no index.

F. H. A. M.

MEMOIRS OF THE GEOLOGICAL SURVEY OF SCOTLAND. THE GEOLOGY OF THE GLASGOW DISTRICT. Second Edition. Revised by M. MACGREGOR, M.A., B.Sc., C. H. DINHAM, B.A., E. B. BAILEY, M.C., B.A., and E. M. ANDERSON, M.A., B.Sc. pp. xi + 299, with 30 text-figures and 1 folding plate. 1925.

GLASGOW is situated in the midst of a district unrivalled in the British Isles for the variety and interest of the geological sections available within a short distance of the city. Students, teachers, and researchers are alike fortunate in having this instructive and fascinating geological region within easy reach, and in being catered for so satisfyingly by the Geological Survey, through the *Glasgow Memoir* and its new edition now under review. There are many additions of fact, but few changes of form, in the new memoir. The mode of treating the Carboniferous strata has been somewhat recast to accommodate new knowledge; but the chief variation from the old edition is that the long economic chapter of the latter is now restricted to limestones, road-metals, building-stones, and water-supply, while the matter dealing with coals, ironstones, and fireclays, has been transferred to the appropriate stratigraphical sections. There is a considerable expansion of the description of the Upper Sedimentary group of the Calciferous Sandstone Series, including a discussion of the Hurlet datum line, the basal volcanic detritus and its overlap relations, and much new stratigraphical material, in accordance with the intensive investigation of this part of the formation in recent years by several Glasgow workers and the officers of the Survey. The base of the Carboniferous Limestone Series is now placed at the base of the Hurlet horizon, that is, at the Hurlet Coal where this seam is present, but at the Limestone itself or the alum shale when the coal is absent. Hence the entomostracan (white) limestone, formerly included in the Hurlet horizon, is now described along with the Calciferous Sandstone sediments. The middle group of the Carboniferous Limestone Series is now called the Limestone Coal group instead of Coal and Ironstone group as in the earlier edition of the memoir. The Carboniferous Limestone Series chapter has an improved geographical subdivision and arrangement. The massive sandstone below the Index Limestone in the Glasgow district is now called the Cowlairs Sandstone. In the first edition it was correlated with the Dullatur Sandstone, which is, however, known to overlie the Index Limestone.

In the chapter on the igneous rocks the mistakes of "Cathcart" for "Cathkin" in referring to the Cathkin Braes to the south of Glasgow (p. 135), and of "Balglass" for "Dunglass" in referring to the beautiful columnar plug of the Blane Valley (p. 144), remain uncorrected from the old edition. It has been overlooked that there is now a full statement available of the sequence of the Lower Carboniferous lavas in the Kilpatrick Hills for comparison with that of the Campsie Fells. The fine columnar section ("Glasgow Staffa") of the Cathkin Quarry (p. 141) which was described by the Rev. David Ure in 1793, has been destroyed by the reopening of the quarry, but it may be worthily replaced by the good columnar section exposed at Craigangawn Quarry in the Kilpatrick Hills, or by the basaltic plug of Dunglass.

A summary discussion of the evidence for the Permo-Carboniferous age of the east-west quartz-dolerite dykes and the accompanying sills of the Midland Valley of Scotland, which are to be dealt with at greater length in the forthcoming memoir on Sheet 31, is given; and while it must be admitted that the evidence is strong, the writer does not believe it to be conclusive. The "limited miscibility" explanation of the pale acid veins in the quartz-dolerites has been dropped in this edition in favour of the theory of differentiation by partial crystallization.

In this edition a much fuller account than in the old memoir is given of the complicated anticlinal structure near Kilsyth called The Riggin, and it is illustrated by a new and most instructive section.

The chapter on Pleistocene and Recent Deposits has been but slightly altered. Some of the sections mentioned, such as the one-time excellent section of boulder-clay overlying contorted sands in a pit south of Bearsden Station, have long ago become unrecognizable.

In the Economic Geology chapter, dealing with limestones, road-metal, building stones, and water supply, the information seems to have been reprinted from the first edition with but little re-arrangement, and with practically no new material. Hence in parts it is somewhat out of date. Cranhill Quarry, for instance, which is stated to furnish setts, cubes, flats, and road-metal, has been closed for many years, even before the date of the old memoir; but many new quarries have been opened in the teschenites, and there is greatly increased activity in some of the old quarries, in order to meet the great demand for road-metal, etc., consequent upon the new road and housing schemes in the West of Scotland.

While the new memoir is a very full and satisfactory account of the geology of the Glasgow district, as valuable as ever to the geological student and teacher, the mining and civil engineer, and to the general public, the professional reader familiar with the old memoir nevertheless experiences a slight feeling of disappointment; as, except in the cases of certain phases of stratigraphy, and the account of coals, etc., those responsible for the new memoir do not seem to have taken full advantage of the wealth of new information, especially in regard to the volcanic geology and petrology of the district. This is probably, however, not their fault, as they were doubtless constrained by limitations of space, and by the necessity of stressing the stratigraphical and economic sides of the subject.

G. W. T.

NOTE ON THE GEOLOGY OF THE FELIXBURG GOLDFIELD. By A. M. MACGREGOR. Southern Rhodesia Geological Survey, Short Report, No. 18. Issued 30th October, 1925, pp. 1–6, geological sketch-map.

THIS field situated 70 miles east of Gwelo has a general east and west trend, parallel to the foliation of the Basement Schists, which here consist of the usual epidiorites and banded ironstone.

The latter is a "quartz-magnetite-haematite rock of supposed sedimentary origin", with the former are associated some biotite-schists. The southern portion of the country shown on the map consists of granite intrusive into the schists, and the whole was probably once covered by Karroo Beds of which the remains, as well rounded sand grains but few outcrops, form much of the northern part of the area.

Brief notes on the mines are given; the gold-bearing quartz reefs, occurring along two principal lines of fissure in the epidiorite, are narrow, a characteristic of the gold being the low silver content. Since 1909, except for a short period, little important work has been done.

J. P.

THE JAPANESE EARTHQUAKE OF 1923. Publications of the Imperial Earthquake Investigation Committee in Japanese. No. 100A, 353 pp. and 55 pls.; No. 100B, 126 pp. and 48 pls.; No. 100E, 296 pp. and 42 pls.

THE great Kwanto earthquake, as it is called in Japan, occurred on 1st September, 1923, and it is a wonderful result that, within about two years these three volumes of the official report should be published. They naturally appear in the first instance in Japanese. Before long we shall no doubt see them, or, at any rate, the sections of directly scientific interest, translated into English.

In succeeding so experienced a leader as the late Professor Omori, Professor Imamura would in any case have found a difficult task to carry on the high traditions of the office, and he and his colleagues are greatly to be congratulated on their production of this remarkable report on one of the most complex earthquakes known to us.

The first volume (No. 100A) is of purely seismological interest. It contains general accounts of the earthquake by Professor A. Imamura and Professor S. Nakamura, illustrated by numerous seismograms, studies by Professor T. Matuzawa and Mr. N. Nasu on the distribution of intensity in Tokyo and other cities, and Mr. T. Yasuda's valuable list of after-shocks recorded in Tokyo. In the second volume (No. 100B) we have a geological study of the earthquake by Professor T. Kato and a physiographical investigation by Professor N. Yamasaki, reports (with excellent maps) on the changes of level in the bed of Sagami Bay and its coast-line by Major-General H. Oomura, Vice-Admiral T. Utida, and others, and accounts of the seismic sea-waves by Messrs. T. Ikeda, T. Terada, and S. Yamaguti, with reproductions of the mareograms obtained in the ports of Japan. A somewhat unexpected result shown in the map of isoseismal lines is that most of Tokyo lies outside the curve that passes through places in which five per cent. of the houses were destroyed by the actual shock. The third volume (No. 100E) relates entirely to the great fires that broke out in Tokyo and other cities in the central area.

C. DAVISON.

THE SURFACE-HISTORY OF THE EARTH. By J. JOLY, Sc.D., F.R.S. pp. 192, with xiii plates, 11 text-figures, and a coloured folding map. Oxford: Clarendon Press, 1925.

IN this well-produced book Professor Joly gives in a handy form a summary brought up to date of the ideas that he has put forward in earlier publications, books, lectures, and memoirs in scientific journals, as to the causes that have been operative in producing the present condition of the earth, regarded as the result of processes occurring during the course of geological history. The special value of Professor Joly's work, as is well known, lies in his application of the phenomena of radio-active disintegration to geological problems, and there can be no doubt that this factor has been of the greatest importance in determining the course of the earth's thermal history throughout the ages. It is obvious that the distribution of underground temperature must have influenced powerfully the movements of the crust and of the subjacent layers. The doctrine of isostasy is now accepted, probably by everyone, and the periodical fusion and resolidification of the basaltic substratum, postulated by Professor Joly on experimental and theoretical grounds, renders much easier the conception of vertical and lateral movements of the floating continental blocks, as required by that theory. It is to be noted that the thickness here accepted for these blocks, on different lines of evidence, is only about 20 miles.

Another point of importance to which reference may be made here is the bearing of Professor Joly's theories on the problem of continental drift. Very great importance is attached to the effect of tides in the molten basaltic substratum, and the escape of superfluous heat and cooling down of this layer after fusion is largely attributed to slipping round of the continents, thus exposing the heated material formerly under them to the chilling effect of the oceans. It is unnecessary here to expound the author's theories in detail, since a fairly long summary of one of the original publications was given in this Magazine two or three years ago (Vol. LX, 1923, p. 521).

This book will be of the greatest possible value as a readable and to some extent more popularly presented account of the whole matter. It contains much food for thought, and should be read by all geologists interested in the problems of earth-history either from the cosmogonic or the stratigraphical standpoint. The explanation thus afforded of great marine transgressions and regressions is amply sufficient to account for the occurrence of these phenomena; the only doubt raised in the reviewer's mind is whether it does not sometimes prove too much, so that at times of maximum depression of the continents there would be very little dry land left, while it is quite clear that certain large parts of the world have very rarely been covered by the sea. In South Africa, for example, there are no marine deposits later than the Devonian, except for narrow fringes of Cretaceous and Tertiary round the coasts, which is inconsistent with the occurrence of periodic risings and sinkings of the continent on a large scale. Further, it may be noted that the major orogenic revolutions do not synchronize all over the world as they ought to do on this supposition.

Very wisely some of the more technical details have been relegated to appendices, and the book concludes with a reprint of a lecture delivered to the Geological Society of London in May, 1923, wherein the whole subject is summed up very briefly. There are some very beautiful illustrations in the form of plates, depicting striking examples of surface denudation as seen in the Alps and in the Colorado Canyon, and two photographs of haloes produced in mica by radio-activity, as well as a coloured bathy-orographical map of the world, showing especially volcanic areas and ocean deeps.

R. H. R.

MOLYBDENUM: METALLURGY AND USES, AND THE OCCURRENCE, MINING AND CONCENTRATION OF ITS ORES. By V. L. EARDLEY-WILMOT. pp. xii + 292, with xi plates, 55 text-figures, and 3 folding maps. Canada, Department of Mines, Ottawa, 1925.

DURING the last months of the war and shortly thereafter, the writer of this review was engaged in the writing of a monograph on molybdenum, and therefore had experience of the difficulty of obtaining reliable information as to the occurrence of the ores of this metal in many parts of the world. It was then only in Canada and Australia that the geology of the deposits had been properly worked out. For the rest of the world the data were extremely scrappy. The account then given of the important occurrences in Norway was so mangled by an incompetent editor after the writer had, as he supposed, finally revised the proofs, that as published it was nonsense. Hence this present memoir is all the more welcome. As is only natural, the greater proportion of the space is devoted to the Canadian occurrences, and the bias is towards ore-dressing and metallurgy rather than to geology. Nevertheless, the information given as to the molybdenum deposits of the rest of the world appears to be very accurate and complete, although condensed into some 30 pages. There is also a valuable bibliography of 10 pages, which should be of great value to all interested in this metal, which appears to have a great future as a constituent of special steels and other useful alloys, as well as a variety of other industrial and scientific uses.

GUIDE TO THE COLLECTION OF METEORITES, BRITISH MUSEUM (NATURAL HISTORY). pp. 43. London, 1926. Price 6*d*.

ALTHOUGH the study of meteorites is usually regarded as belonging rather to mineralogy than to geology, nevertheless it has a deep interest in connexion with some of the recent speculations as to the composition and zonary structure of the earth's interior. It is highly tempting to believe that the meteorites furnish us with a collection of samples of a burst planet, and then to conclude from analogy that the earth must have a similar composition. There is, however, here a great danger of arguing in a circle, a danger which has not always been successfully avoided in recent writings.

In addition to the nickel-iron, perhaps the most noteworthy features of the composition of meteorites in general are the abundance of sulphides and the comparative scarcity of oxygen: it is interesting to find a mineral (daubreelite) which is the exact sulphur analogue of chromite.

If the meteorites really are remains of an exploded planet, we are almost driven to conclude that this planet had no acid shell, as the earth certainly has. At least no specimens of such are known. Only one meterorite is known with free silica, and this is tridymite, not quartz.

LEITFOSSILIEN. Ein Hilfsbuch zum Bestimmen von Versteinerungen bei geologischen Arbeiten in der Sammlung und im Felde herausgegeben von GEORG GÜRICH. Vierte Lieferung: LEITFOSSILIEN DER TRIAS. Wirbellose Tiere und Kalkalgen von C. DIENER. Mit 28 Tafeln, pp. 118. Berlin: Borntraeger, 1925.

THIS work gives excellent figures and brief descriptions of the important fossils of the marine Trias, and concludes with correlation tables of the Triassic deposits in various parts of the world. Lists of some of the chief memoirs dealing with each of the groups of fossils are given. For use in the field and for students who have not access to a good collection this work should be of great service.

TYPE AMMONITES.—V. By S. S. BUCKMAN, with contributions from J. W. TUTCHER, W. J. ARKELL, C. C. GADDUM, J. PRINGLE, A. E. TRUEMAN, D. M. WILLIAMS. Vol. V, pp. 1–88; Text-figures 1–8. Plates 194 and 6 re-issued. Published by the Author. Sold by Wheldon & Wesley, Ltd., London, August, 1925. Price £6.

THE text of this volume deals mainly with the importance of proportions taken at the three points as checks in the identifications of species and as furnishing evolutionary data when reduced to graphs; and with the detailed chronology of the deposits commonly known as "Corallian".

BOLETIN DE LA SOCIEDAD GEOLÓGICA DEL PERÚ. Volume I. Lima, 1926.

THE Geological Society of Peru, which owes its inception principally to Professor C. I. Lissón of the University of San Marcos, held its inaugural session on 11th November of last year, when the President of the Republic was present.

The list of members contains forty-seven names, many of whose bearers are men of eminence in the scientific life of the country. The formation of this Society marks another stage in the rapid progress of Peru in the Arts and Sciences under the inspiring leadership of Augusto B. Leguía.

Professor Lissón is to be congratulated on his bringing into existence one more factor making for the advance of Geology, since the Republic, nearly twelve times the size of England, and containing 1,300 miles of the Andean Ranges, affords inexhaustible material for geological studies both pure and applied.

This volume of *Transactions* has 126 pages and 32 plates, clearly printed on good paper. It contains five communications, all of interest.

Professor Lissón, whose name is well known for his works on Cretaceous fauna as well as for his physiographical studies, contributes two papers ; in one he describes some ammonites, of which one belongs to a new species, and some new gasteropods ; in the other, on the Palaeogeography of Perú, he explains the genesis of the terrain in an argument well brought out by a series of maps. Starting in Palaeozoic times with a geosynclinal between the Brazilian shield and a hypothetical (northern) " Coastal Cordillera ", there ensued successive additions of land belts in Mesozoic and Tertiary times on the western shores due to the uprise of the Oriental, the Central, and the Western Cordilleras (in that order of succession). Equally, the geosynclinal sea shifted laterally to the west, and the Coastal Cordillera, north of latitude 14° N., disappeared by submergence (probably, we suggest, because of the geofault noted by Bosworth) and denudation in Quaternary times.

E. I. Dueñas writes on the fundamental physiographical features of the Peruvian terrain, a paper which, though highly technical, is extremely interesting. J. A. Broggi gives a short paper on the underground course of the Yauli River, an affluent of the Mantaro. Atmospheric waters, deriving lime from Cretaceous rocks of the flanking hills, emerge as springs near both sides of the river, and there deposit travertine to such an extent in the neighbourhood of the village of Saco, that eventually a natural bridge 400 metres wide has been formed, over which the railway from Callao to Huancayo has been carried. R. A. Deustua contributes an account of the petroleum fields, which, however, lacks novelty, with a number of very good photographs. Plate XVI, which seems to represent country familiar to us, does not show " the 3 different Tablazos ", as stated in the descriptive text, but harder beds of shelly limestone 30 or 40 feet apart in the deposits forming the Máncora Tablazo.

The high level attained by this first volume is of good augury for the future of geology in Peru.

C. B. B.

THE GEOLOGY OF THE COUNTRY AROUND BIRMINGHAM. By T. EASTWOOD, T. H. WHITEHEAD, and T. ROBERTSON, with contributions by T. C. CANTRILL. Mem. Geol. Surv., Explanation of Sheet 168. pp. xvii, 152, 7 plates, 1 text-figure. 1925. Price 4s.

THIS memoir describes the geology of 216 square miles of country around Birmingham, represented on the colour-printed geological 1 in. map (Sheet 168). It is the first time that the Survey have published a memoir dealing specially with the Birmingham district, although part of the area falls within that described in Jukes' classic memoir on the South Staffordshire Coalfield, published in a second edition in 1859, while Howell's Warwickshire Coalfield, 1859, dealt with the eastern fringe of the district now under review. Since that time, as one would expect, many new discoveries have been made in the district, and the Director of the Survey pays a graceful tribute in the Preface to the geological work in the Midlands of the late Professor Charles Lapworth and his pupils.

The south-eastern part of the South Staffordshire Coalfield comes into this area, and is dealt with in detail. It is welcome news to hear that the economic geology of the whole coalfield south of the Bentley Fault is to appear shortly as a separate memoir. With regard to the classification of the Carboniferous and Permian rocks, a notable departure is the decision of the Survey, for the present at all events, to relegate all the red rocks between the Keele Beds and the Bunter to the Carboniferous, under the term Enville Beds. Thus the old "Permian Question", so far as the Midlands are concerned, would seem to be disposed of by regarding the Permian of Hull and King (above the Keele Beds) as part of the Stephanian of continental geologists. One wonders whether the Permian of the north of England is to suffer a like, though not identical, fate, for it is well known that an officer of the Survey, unofficially it is true, is eager to assimilate it with the Trias.

There is a valuable appendix containing the records of over a hundred wells and boreholes; but, apart from this, four pages seem a little scanty to devote to economics, seeing that the work is meant to serve a great industrial area.

We note a welcome improvement in paper, print, and cover, as compared with some earlier memoirs. The low price and great value of the work should ensure a ready sale, and when a second edition is called for, it will be possible to correct a few minor errors, which have already been detected through the opening up of new ground since the survey was completed.

The authors of the memoir are to be heartily congratulated on their lucid, accurate, and conscientious work.

REPORTS AND PROCEEDINGS.

THE ROYAL SOCIETY.

28*th January*, 1926.

A. C. Seward, F.R.S.: "The Cretaceous Plant-Bearing Rocks of Western Greenland."

In 1921 the author, with financial assistance from the Royal Society's Government Grant and the Worts Fund (Cambridge), spent rather more than two months in Western Greenland, collecting fossil plants; he was accompanied by Mr. R. E. Holttum, who ably assisted him and made large collections of recent plants. The present paper deals briefly with the geology of the localities visited, and, more fully, with the plants collected on the coasts of the Nügssuak Peninsula and on the south-east coast of Disko Island. The fossils obtained include many species previously described by Heer, most of whose type-specimens have been examined in the museums of Copenhagen and Stockholm, and compared with the illustrations in the *Flora Fossilis Arctica*. Species are described, and most of them illustrated, in the full paper, as follows:—

Filicales, twenty species; *Incertae sedis*, two species; *Cycadophyta*, eight species; *Ginkgoales*, six species; *Coniferales*, twenty species; *Monocotyledoneae*, four species; *Dicotyledoneae*, seventeen species; *Incertae sedis*, eight species. *Fossilis incertae sedis—Fasciculites groenlandicus* Heer.

In the concluding section the question of Geological Age is discussed. Reasons are given for regarding, for the present, the Cretaceous plants from Greenland as a single flora, and it is pointed out that Heer's threefold division (Kome, Atane, and Patoot series) cannot be accepted as an entirely satisfactory classification of the Greenland beds. Attention is called to the association in Greenland of several species of Ferns and Gymnosperms, which in other parts of the world are characteristic of the oldest Cretaceous floras and closely allied to Jurassic types, with representatives of Angiosperms that are strikingly modern in the form and venation of the leaves.

The Greenland flora is compared with floras of Lower and Upper Cretaceous age in different parts of the Northern Hemisphere. The conclusion is that the Greenland Cretaceous flora is Wealden-Cenomanian in age. Reasons are submitted in support of the view that several deciduous Dicotyledons were evolved in Arctic regions where, in Cretaceous days as now, a short summer with continuous sunshine alternated with a long period of semi-darkness. From their Arctic home the flowering plants spread to the South. The Wealden-Jurassic species in the Greenland flora are regarded as elements from older and more southern floras which had wandered into the far North.

The paper concludes with a brief discussion of the Cretaceous climate, and the present geographical distribution of certain families of plants is contrasted with their range in the Cretaceous period.

GEOLOGICAL SOCIETY OF LONDON.

19*th February*, 1926.

"Regions of Compression." Presidential Address by Dr. J. W. Evans, F.R.S.

The characteristic structures of regions of compression—that is to say, folding, thrust faulting, and slaty cleavage—are as a rule the result of horizontal forces ultimately to be attributed to the contraction of the earth's interior as it cools. It has been doubted whether, with the energy released by radioactive elements, the earth cools at all. The whole of that energy is not, however, converted into heat; much must be employed in effecting physical, chemical or atomic changes in the surrounding rock. The substance of the ionized pleochroic haloes in biotite mica is hundreds of thousands of times greater than the radioactive materials of the zircon round which they are formed, and they must represent a relatively enormous absorption of energy.

Jeffreys shows that the contraction on cooling of the crystallized rocks is more than enough to account for the folding of existing mountains. But there are many folds of ancient mountains now worn down which would require still more contraction. This may have occurred in the following ways: (1) the contraction of the uncrystallized magma containing volatile constituents is greater than that of crystallized rocks; (2) the contraction on crystallization is equal to that on a fall of temperature of very many degrees; (3) contraction may take place on changes of crystal structure, chemical composition, or even atomic nature; (4) contraction will result from the loss of volatile constituents; (5) it must also follow on the increase of pressure in the earth's interior due to the slowing down of its rotation. On the other hand, the extent of the crust may be locally *increased* in periods of tension by (1) infilling of rifts by igneous intrusions, and (2) slip faulting, and also by hydration of rocks.

Compression and folding may also result (1) from change in the earth's form on diminished rotation, (2) from change in the position of the crust relatively to (*a*) the poles and equator, (*b*) the maximum of gravitational force.

In illustration of the process of folding, two examples are described (1) the Hercynian or Armorican folding of the south-western peninsula of England and South Wales, (2) what might be termed the Wealden folding between the Thames Valley and the "Massif Central" of France. In the former case it is shown that the accumulations of sediments from mountains formed by Caledonian movements resulted in a "sedimentation subsidence". This was slightly contracted and deepened by early Hercynian compression. This "compression subsidence", allowed still greater accumulations of sediments. The oncoming of the main Hercynian movements contracted much more vigorously the basin of subsidence, forcing up the contained sediments into folds. The accumulated weight of these gave rise to a deep "folding subsidence". A distinction is made between the exterior structure formed from the old floor of deposition and the interior structure consisting of the sediments deposited on it. The outflow of the plastic sima from below the deepened basin raised its southern rim, with the result that in the course of the compression the folds were tilted northwards and dipped to the south. The folds were defined by the calcareous and arenaceous banding; while the argillaceous material between flowed rather than folded; and it is this flow which is now represented by slaty cleavage. In a later stage, both outer and inner structures were traversed by thrusts, that like the folds and cleavage dipped to the south. The greatest of these thrusts brought in the extreme south the pre-Cambrian rocks up against the Palaeozoic. In the south of Devon and Cornwall this and other thrusts drove older rocks over new, but in North Devon new were brought over old. The displacement of the sima in the course of mountain building resulted in the intrusion of basic magmas, while the granites were probably derived from a reservoir beneath the uplifted pre-Cambrian rocks of the south.

The Wealden folding had its origin in sedimentary accumulations in a vast Triassic plain paved with the eroded outcrops of older rocks, and bordered by Hercynian highlands. The sedimentation subsidence was widespread and the compression in late Secondary and Tertiary times deepened it considerably, so that its floor has never been reached by borings to the south of the northern slope of the Wealden anticline, except in the neighbourhood of the Massif Central and the Hercynian heights to the east and west. The actual compression in this region was small compared with that which occurred about the same time in the Pyrenees and Alps, but it threw the sediments of the interior structure into numerous folds.

A brief comparison is made between the great earth movements of the Alps and those which form the subject of the address.

GLASGOW GEOLOGICAL SOCIETY.

11th February, 1926.

"The Apatites in Sedimentary Rocks as Indicators of the Amount of Atmospheric Carbonic Acid in the Periods of Deposit." By Wm. Mackie, M.A., M.D., LL.D.

The solubility of apatite in water is proportional to the CO_2 content of the water. As the CO_2 content of sea-water, river-water, and ground-air varies as the atmospheric content, the variation in the amount of apatite in sediments is due to variation in the CO_2 content of the atmosphere at the time of deposition, the amount of CO_2 in the atmosphere being in inverse ratio to the proportion of apatite in the sediment. Abundance of apatite in a sediment may be accepted with little qualification as indicating that little or no CO_2 existed in the atmosphere of that period. The negative phase calls for investigation. Apatite may be absent because of (*a*) absence or scarcity in rocks yielding the sediment, (*b*) pre-depositional solution, (*c*) post-depositional solution.

Of these (*c*) may render impossible any determination of the conditions prevailing at the time of deposition. The conditions under which the sediments accumulated have to be considered—deposition in sea or fresh water, and the possibility of aeolian attrition. Supplementary evidence as to conditions is furnished by quantitative data of the occurrence of monazite, which is usually found along with apatite, and by the condition of the monazite grains.

The view that the CO_2 content of the atmosphere was greater in the earlier geological periods does not agree with the inference from comparison of the quantitative data of the apatite content. Probably the amount was never much greater than at present, often much less. Torridonian, Cambrian, Lower O.R.S., Carboniferous, and other periods, believed on theoretical grounds to have had higher temperatures than the present day, have also a high content of atmospheric CO_2, confirming the conclusions of Arrhenius, Tyndall, and other physicists that a higher CO_2 content is the cause of higher temperatures.

CORRESPONDENCE.

PLEISTOCENE DEPOSITS OF THE GREAT OUSE BASIN.

Sir,—In the discussion of a paper which I read before the Geological Society on 8th March, Mr. Lamplugh made some remarks to which I could not reply, partly through lack of time, partly because they did not bear directly upon the matter of my paper as delivered, when I confined myself solely to the deposits of the lower part of the Great Ouse Basin.

The correlation of the supposed marine deposits of March with the river-gravels was put forward by the geological surveyors, and is in my opinion supported by the fossil evidence. As the March gravels are now being studied by Mr. F. G. Walker, of Manea, I await the publication of his results.

The assumption that because some of the river-deposits contain a "temperate" fauna, the ice had therefore all gone, has, so far as I know, never been stated by me. In my paper I argued that it had gone from the area under description. The evidence over wide areas is so conflicting that he would be a bold man who made such an assumption.

There appears, however, to be good evidence of marked climatic oscillations over a wide area in this country, e.g. at Hoxne, where beds with a temperate flora overlie boulder-clay and underlie others with an Arctic flora on the Cumbrian coast, where Dr. Bernard Smith has detected a peat with a temperate flora between two glacial deposits, and on the Durham coast, where Dr. Trechmann has found an accumulation claimed as loess similarly intercalated. Then there is the significant section at Kirmington. By the way, if the Kirmington tract was submerged, why not that of March also, lying further south ?

I may note that anyone examining the glacial deposits of the Cambridgeshire plateau might well argue for a single glaciation there, though Messrs. Rastall and Romanes considered that earlier glacial deposits here were ploughed up by, and their contents incorporated with, those of a later period. It is chiefly in the valleys where the gravels were deposited in considerable thickness, and afterwards protected from later ice, according to my view, that the evidence for their intercalation between two periods of glaciation of the district is obtainable.

John E. Marr.

Cambridge.
18*th March*, 1926.

GEOLOGY OF THE EAST INDIES.

Sir,—May I invite the attention of English geologists interested in the East Indies to a book recently published by The Macmillan Company in the U.S.A., *The Geology of the Netherlands East Indies*, by Professor H. A. Brouwer, of Deft. The book is a series of lectures delivered at Michigan University, and is a most valuable summary in English of a mass of Dutch geological literature. On inquiring for the book in England I found it was unknown, even by Macmillan and Company, Ltd., London. It was published in New York in October, 1925.

J. B. Scrivenor.